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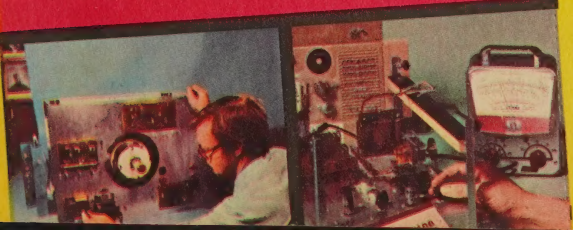

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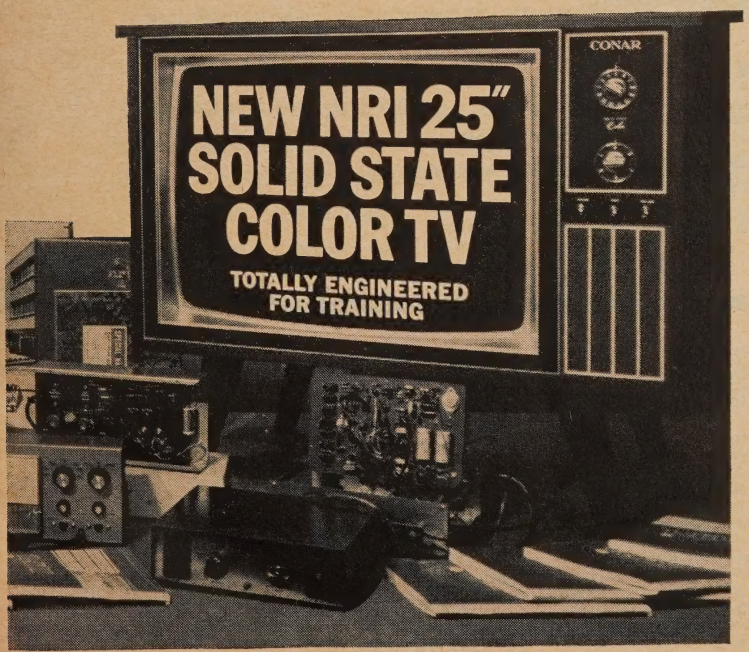

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Editorial

By Milton S. Snitzer, Editor

THE HI-FI POWER RATING HASSLE

About a year and a half ago the Federal Trade Commission (FTC) held an open hearing on hi-fi amplifier power ratings. Their idea was to issue a rule on how the ratings were to be promoted and advertised. Long overdue, the rule would be a giant step forward in clearing up the confusion that exists.

We've all seen ads and catalogs giving amplifier power in terms of instantaneous peak, peak, dynamic, music, IHF, EIA, and continuous or average (incorrectly called "rms") power. Depending on which power is given, a stereo amplifier with a continuous power rating of 10 watts per channel could be rated at 20 watts continuous power (total power of both chanels), 30 watts music or dynamic power, 60 watts peak music power, 80 watts peak power at some lower impedance load (say 4 ohms rather than 8 ohms), or 100 watts peak power with only a single channel driven rather than both channels. If the distortion is permitted to be 5 percent rather than say 1 percent, even higher power figures, can be quoted. With this ten to one power ratio possible and with all the figures describing the same ampilfier, it is no wonder that the consumer is baffled and confused.

What the FTC was proposing is a return to the conservative continuous power per channel rating, with all channels driven, and at a given load impedance and specified distortion. They also want the power bandwidth to be expressed by quoting the *minimum* power output of the amplifier over the band. Other power ratings could be disclosed but these would have to be less prominently advertised and promoted.

We are bringing this up now since it was expected that the new FTC rules would be issued by June in time for the Consumer Electronics Show. Instead Federal Courts decided that the FTC had exceeded their authority by publishing any such trade regulations. The FTC is appealing the ruling and they may wind up in the Supreme Court for the final decision. In the meantime any rules promulgated by the FTC are advisory rather than mandatory.

The EIA, in the meantime, went on record as opposing the disclosure of the amount of distortion provided it was 5% or less. "For most consumers" they said, "there will be little or no perceptible improvement in the sound they hear as the total harmonic distortion is reduced below this point." They would like to see as the advertised ratings the sum of the output of each channel rather than a per-channel figure. They also object to the FTC's proposal that the *minimum* power over the bandwidth be quoted rather than the maximum power.

We feel sure that some sort of ruling will come out but that it won't be effective until next June at the earliest. In the meantime we expect to see more and more manufacturers coming around to the FTC's proposal. As for us, we will continue our practice, which has never changed, of specifying loads and distortion and of quoting only the continuous power rating of all the amplifiers we test or that are tested for us by Hirsch-Houck Labs.

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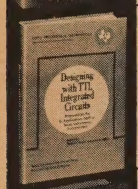

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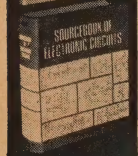

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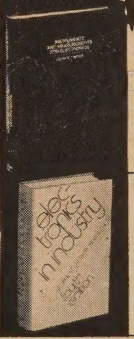

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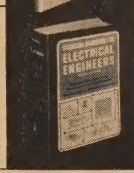

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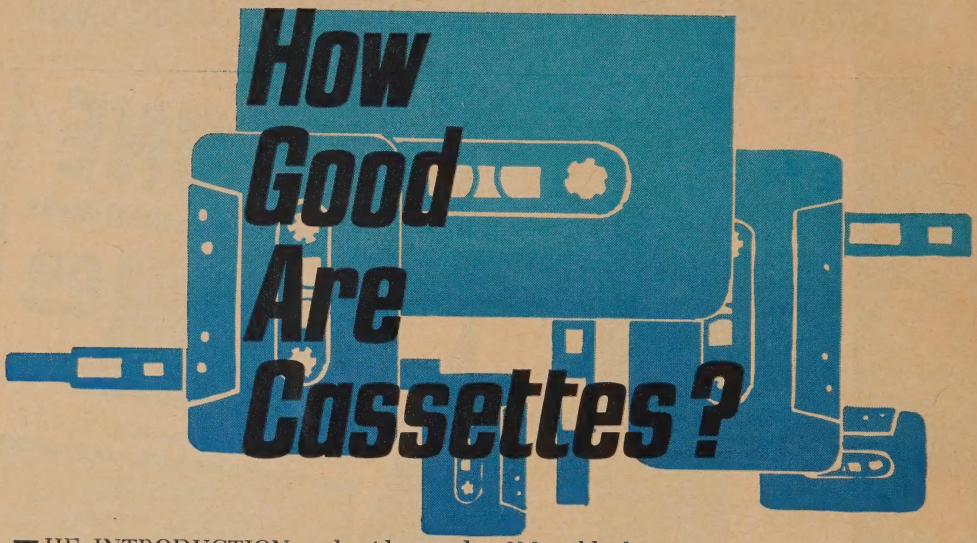

THE INTRODUCTION and widespread popularity of the cassette recording medium in home entertainment have raised many questions by owners and potential owners of cassette equipment—particularly about the cassette itself. Over the years, many people have attempted to answer such questions and explain the pro's and con's of cassettes. Recently, Harry Maynard interviewed Delos Eilers of 3M on the subject of cassettes. The following is the transcript of that interview.

—Editor

MAYNARD: Let us discuss some problems inherent to all cassettes. The first that comes to mind is that they are difficult to edit. Is this correct?

EILERS: Yes. Cassettes are difficult to splice without getting fingerprints on the tape. A cassette tape carries such a narrow track and at such a slow speed that fingerprints can create very large dropouts. If you go across the splice, you are going to hear the dropouts. Another obstacle to the average home splicer is that the 150-mil splicing tape is not readily available to the general public.

M: Whenever I have managed to splice a cassette tape, I feel that I have won a great victory. Scotch recording cassettes pose a special problem for the tape splicer: 3M welds their cassettes, making them impossible to open and edit. Other manufacturers assemble their cassettes with screws. Why did 3M go to welding?

E: We elected this method because we feel that it makes the cassette stronger and more rigid. As machines and cassettes get better, I think you will find that all cassettes will be welded. We realized when we went to welded cassettes that splicing would be a problem. Our answer was to build a cassette component that is reliable enough so that there should be no need to repair it.

M: A BASF executive recently wrote that the reliability of cassettes still leaves something to be desired. Would you care to comment?

E: Any system—whether cassette, 8-track cartridge, or some of the new BASF systems—has to go through an evolution before it is mechanically reliable. An approach toward better reliability is welding—in 3M's case, sonically sealing—the cassettes.

M: What do your studies show is the reliability factor of cassettes?

E: Cassettes are not 100-percent reliable; but what is? The 60-minute (C-60) cassette is the most reliable as compared to the C-90's and C-120's. We conducted long, involved statistical experiments using several hundred cassettes to test reliability. We found that 95 percent of the C-60's tested

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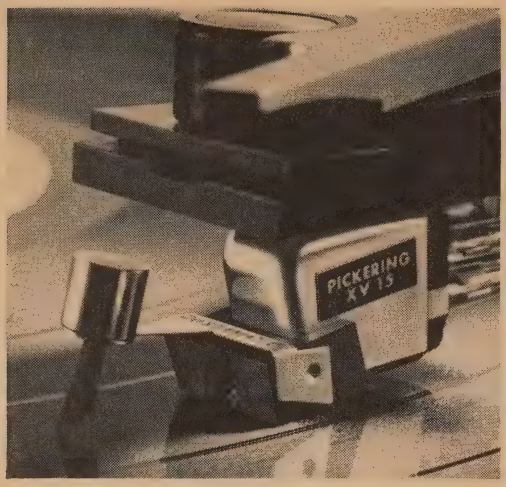

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The C-90's and C-120's are less reliable. Our research and development people are trying to find the answers, especially for the C-120's. It and the machines have to be improved. We are looking for ways to make a more perfect marriage between the tape and the machine.

M: What part of failure would you blame on the cassette? What part on the machine?

E: Any number of things can go wrong with a cassette, the more so with the "cheapies." For example, all the parts of a cassette may be 100 percent up to tolerance but poorly assembled. The inside housing of the cassette may not allow enough room for the tape to pass through.

We had that problem some years ago with a cassette that had a glue-in window. Some of the windows were not seating themselves all the way in the cassette. They hung down into the area where the tape should have been turning and winding. This added drag on the tape.

I have seen jammed cassettes where the hub was perfectly free. The trouble was that the capstan was not driving the tape in a straight line because a small pinch roller in the machine was not meeting the capstan squarely. The tape began to climb off the capstan, eventually breaking.

Philips has quite a reasonable list of performance specifications which cassettes should meet. Our parts are checked and are, in design, 100 percent correct. A high percentage are quality tested for meeting torque requirements—the force it takes to turn the hubs in a cassette.

I have seen cases in battery-operated machines where the batteries were so run down that they could not turn the cassette reel.

M: Would you advise running a cassette recorder off ac power whenever possible?

E: Yes.

M: Is there an easy way for the consumer to evaluate a cassette without running a frequency response check and without opening the cassette?

E: There is quite a variety of cassette tapes available. The first suggestion I have is to avoid cheap cassettes.

M: Can the consumer examine the type of pressure pad used, see if the tape is polished, and check to see that the cassette halves fit together?

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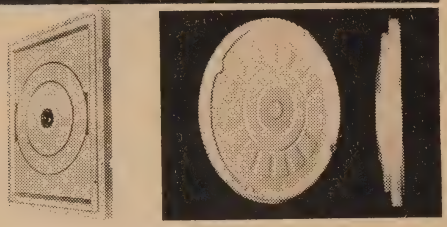

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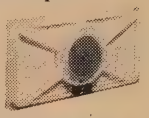

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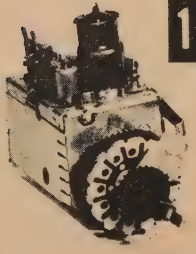

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CIRCLE NO. 27 ON READER SERVICE CARD

E: If the buyer is interested in recording music, he should look only at tapes with some kind of surface polish. This generally indicates a better cassette.

M: What suggestions would you have which will help the consumer faced with deciding which cassette to buy among ten shown to him?

E: Check to see if the oxide coating comes off on your fingernail. The cheap cassettes are generally not formulated with the same care as are the better tapes.

M: Why did 3M decide on fixed posts when most of the other cassettes on the market employ roller guides?

E: The original Philips cassette design was for roller corner turnaround posts in the front corners of the cassette. If you look at a cassette, you will note that the tape opening is in front. Roller guides have virtues, but they have some disadvantages we want to avoid. The roller guide is a steel axle pin and roller with guides or shoulders at the top and bottom. These parts must be assembled perfectly or the tape will be steered incorrectly and will drag and bind.

M: You avoid this?

E: We use a precision molded part with stationary posts to insure that the corner post is absolutely perpendicular to the plane of the deck. The tape is not forced upwards or downwards.

M: What is the major failure problem in cassettes?

E: The classical failure is when the takeup hub stops. The machine's torque and clutch mechanism cannot turn the takeup hub. The capstan still pulls tape off the supply reel, but the takeup hub is not taking up this tape.

M: Is this a machine or a cassette problem?

E: It can be either. With a battery-operated machine, it is more likely the machine's fault. It can be a cassette problem in that the cassette may be dragging. This failure is catastrophic because tape piles up around the capstan and has nowhere to go. The small hole around the capstan gets crammed full of tape. In some cases, you cannot even get the cassette out of the machine because of the jammed tape. The tape then must be cut.

In less drastic cases, where the tape does not wind well, I suggest that the cassette be removed from the machine and slammed flat on a table. Mind you, I do not suggest that this works all the time.

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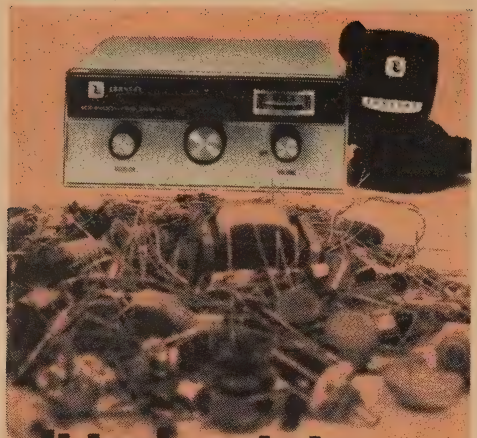
CIRCLE NO. 32 ON READER SERVICE CARD



It took guts to redesign a CB radio and then put it in the same familiar cabinet.

We know today's CBer is looking for real value. So we redesigned our Messenger 123 where it counts—on the inside. Our engineers gave the model "A" new improved circuitry. With a new acoustically isolated speaker and voice-tailored audio that cuts noise—increases clarity. Plus a new ceramic selectivity filter that rejects adjacent channel chatter. And, of course it has built-in electronic speech compression for famous Johnson "talk power." At $149.95, the Messenger 123A is a real value. And come to think about it, it's still a great *looking* CB radio just the way it is.

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CIRCLE NO. 21 ON READER SERVICE CARD

M: Is it true that the quality of the tape is ahead of the quality of the recorder?

E: Yes. The oxide in the cassette has not yet been pushed to its limit. The trouble is with the resolution on playback. The playback head leaves something to be desired. You are putting a given frequency of tone information on a very small area of tape. This tape is also running very slowly—roughly 2 in./second. It is quite a job putting 15,000 little sound waves on every 2 in. of tape. The gap in the head actually approaches the length of the signal recorded on the tape when, ideally, it should be 25 percent smaller than the wavelength of the highest frequency tone to be put on the tape.

M: Is the next improvement in cassette recorders going to be in the heads?

E: I believe so. 12,500 Hz is very adequate for audio recording. We have long known this in professional areas. Many people talk in the area of 20,000 and 22,000 Hz, which are great figures for amplifiers and electronics. But if you have a tape-limited response out to 10,000 or 12,500 Hz, you have a recording that is very difficult to distinguish from the original source.

M: What about chromium dioxide tapes?

E: A tape of higher coercivity such as chromium dioxide is a product that is not as sensitive as standard oxide tapes are at most frequencies. This can be a problem unless you use a machine that can handle chromium dioxide formulations. It takes more drive to get the same sound out of chromium dioxide as you get out of a standard iron oxide tape. Chromium dioxide takes about 25 percent more signal and 2½ times more drive than does a standard iron oxide tape to achieve the same output.

You have to design a new machine around chromium dioxide tapes. Wollensak and Advent have done this. Their machines record with an exaggerated high end. On playback, the frequency response is changed so the frequency response curve comes out flat. When they bring the high end down, these recorders bring back down the tape noise on playback.

Chromium dioxide is less sensitive at the low end than are standard tapes. So, you have to flip a switch on recording to put 50 percent more bias and 25 percent more level on the tape. On playback, you have to flip the switch to the CrO_2 setting to assure a flat frequency response. ◈

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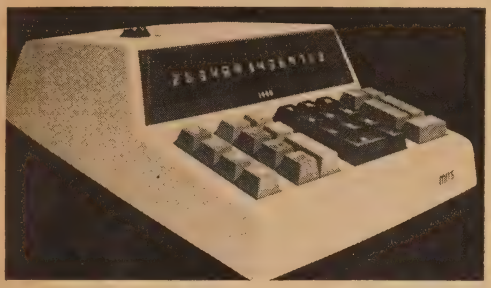

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16 digits, the highest output capacity of any MITS calculator, are available on the 816 models only. Constant data memory and computed fixed decimal system makes the 816 a useful tool for business or home use.

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JERMYN

CIRCLE NO. 20 ON READER SERVICE CARD

Needs Tube Tester Manual

I recently obtained a tube tester, Model 599-A, made by Supreme Instruments Corp. of Greenwood, Mass. Unfortunately, no instruction manual came with the instrument, which incidentally, is in operating order. My problem, lacking a manual, is that the tester has several functions that I am at a loss to decipher. I have tried in vain to track down the manufacturer. Can anyone help me?

MARK WALLACE
201 Pleasant St.
Greenfield, MA 01301

If anyone can help, please write directly to Mark.

Med Electronics Course Booster

While reading the Letters column in your March 1972 issue, I happened across a reader's request for some form of medical electronics course. This item interested me since I am at present enrolled at the University of Waterloo where I hope to be doing graduate work in medical electronics. I must admit that the type of course which integrates medicine and electronics is a rarity.

My own particular interest is in the area of communication and medical aids for the handicapped. I have had some experience with the Ontario Crippled Childrens' Centre in Toronto which points out the tremendous opportunities for people who have the combination of medical and electronics skills.

I think that if you could do some prodding to get such a course started, it would be a step in the right direction. Even if the course merely involved the use of hospital electrical apparatus, it would be worth it.

PETER NEWBY
Niagara Falls,
Ontario, Canada

We agree that there is a pressing need for suitably trained medical electronics technicians, and so do the home-study schools—up to a point. Past experience with surveys have shown that there is just not enough interest in this area for the schools to make the tremendous investment such an undertaking would involve. In fact, our own survey yielded only 52 letters

in favor of a medical electronics course—and yours was number 52.

Popular Electronics For Sale

I am offering for sale a complete set of POPULAR ELECTRONICS from the October 1954 through the December 1964 issue (Volumes 1 through 21) for $65.00 postpaid. All issues are in mint condition.

TOM ROSE
3410 Rockbluff Dr.
Dallas, TX 75227

Interested readers, please write directly to Tom.

More Surplus Nostalgia

Mr. Chesson's letter ("Letters," June 1972) concerning early Courtland Street's radio conglomeration brought back memories. I assure Mr. Chesson that there are a few old timers around. Old Courtland St. and its radio bargains seem only a few short years in the past. (Please note that it was "radio" in those days—"electronics" had not arrived.)

During 1924-1926, when shipping out of New York, I often browsed around Courtland St. radioland. One day I found an old Canadian Marconi spark transmitter, complete with rotary gap. At this time, Courtland St. was the resting place for surplus WWI spark equipment like the Navy's SE-143's and SE-1220's, Navy Standard 1 and 2-kW spark transmitters, and a few Marconi P-4's and P-8's. All used quenched gap sections, making salvage worthwhile.

EDWARD C. CAFFERY
San Antonio, Tex.

Getting "Surf" From Synthesizer

After assembling the Surf Synthesizer (Feb. 1972), I ventured to the Pacific Ocean along the Mexican coast to listen. Guess what? The real ocean (at least there) doesn't sound like the synthesized ocean. The real ocean's cycles are longer and, as the foam breaks on the beach, the hiss has a different roar/rumble characteristic. The PAIA circuit also produces a "pop" every two minutes or so as the flip-flops get synchronized at their switching points.

To eliminate the pop, lengthen the cycles, and produce higher hiss tones from my Synthesizer, I made the following changes: I reversed D1 first. Then I substituted 270 k, 33 k, 160 k, 22 k, 560, and 22 k values in place of those called for in the Parts List for R3, R13, R7, R14, R11, and R15, respectively. Finally, I changed the value of C3 from 30 µF to 80 µF. Now, the sound from the Synthesizer sounds more like the real thing .

G. L. ARROYO
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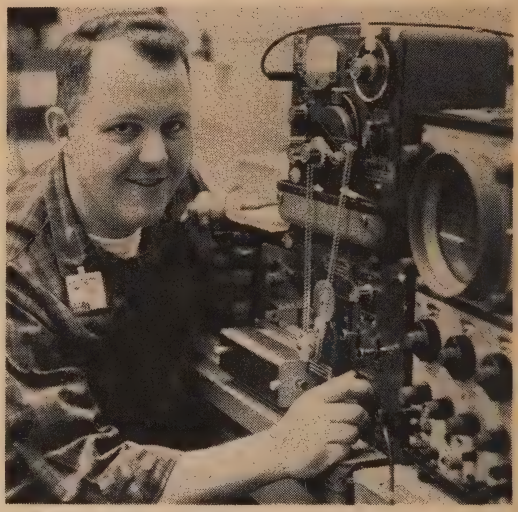
One of our most successful students wrote this ad!

Harry Remmert decided he needed more electronics training to get ahead. He carefully "shopped around" for the best training he could find. His detailed report on why he chose CIE and how it worked out makes a better "ad" than anything we could tell you. Here's his story, as he wrote it to us in his own words.



Harry Remmert gives his CIE Electronics course much of the credit for starting him on a rewarding career. He tells his own story on these pages.

By Harry Remmert

"AFTER SEVEN YEARS in my present position, I was made painfully aware of the fact that I had gotten just about all the on-the-job training available. When I asked my supervisor for an increase in pay, he said, "In what way are you a more valuable employee now than when you received your last raise?" Fortunately, I did receive the raise that time, but I realized that my pay was approaching the maximum for a person with my limited training.

"Education was the obvious answer, but I had enrolled in three different night school courses over the years and had not completed any of them. I'd be tired, or want to do something else on class night, and would miss so many classes that I'd fall behind, lose interest, and drop out.

The Advantages of Home Study

"Therefore, it was easy to decide that home study was the answer for someone like me, who doesn't want to be tied down. With home study there is no schedule. I am the boss and I set the pace. There is no cramming for exams because I decide when I am ready, and only then do I take the exam. I never miss a point in the lecture because it is right there in print for as many re-readings as I find neccessary. If I feel tired, stay late at work, or just feel lazy, I can skip school for a night or two and never fall behind. The total absence of all pressure helps me to learn more than I'd be able to grasp if I were just cramming it in to meet an exam deadline schedule. For me, these points give home study courses an overwhelming advantage over scheduled classroom instruction.

"Having decided on home study, why did I choose CIE? I had catalogs from six different schools offering home study courses. The CIE catalog arrived in less than one week (four days before I received any of the other catalogs). This indicated (correctly) that from CIE I could expect fast service on grades, questions, etc. I eliminated those schools which were slow in sending catalogs.

FCC License Warranty Important

"The First Class FCC Warranty* was also an attractive point. I had seen "Q" and "A" manuals for the FCC exams, and the material had always seemed just a little beyond my grasp. Score another point for CIE.

*CIE backs its courses with this famous Money-Back Warranty: when you complete a CIE license preparation course, you'll be able to pass your FCC exam or be entitled to a full refund of all tuition paid. Warranty is valid during completion time allowed for your course.

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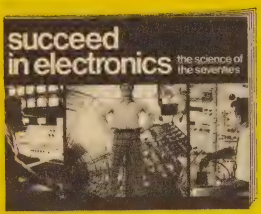

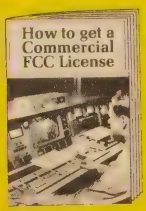

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"Another thing is that CIE offered a complete package: FCC License and technical school diploma. Completion time was reasonably short, and I could attain something definite without dragging it out over an interminable number of years. Here I eliminated those schools which gave college credits instead of graduation diplomas. I work in the R and D department of a large company and it's been my observation that technical school graduates generally hold better positions than men with a few college credits. A college degree is one thing, but I'm 32 years old, and 10 or 15 years of part-time college just isn't for me. No, I wanted to *graduate* in a year or two, not just *start*.

"When a school offers both resident and correspondence training, it's my feeling that the correspondence men are sort of on the outside of things. I wanted to be a full-fledged student instead of just a tag-a-long, so CIE's exclusive home-study program naturally attracted me.

"Then, too, it's the men who know their theory who are moving ahead where I work. They can read schematics and understand circuit operation. I want to be a good theory man.

"From the foregoing, you can see I did not select CIE in any haphazard fashion. I knew what I was looking for, and only CIE had all the things I wanted.

Two Pay Raises in Less Than a Year

"Only eleven months after I enrolled with CIE, I passed the FCC exams for First Class Radiotelephone License with Radar Endorsement. I had a pay increase even before I got my license and *another* only ten months later.

"These are the tangible results. But just as important are the things I've learned. I am smarter now than I had ever thought I would be. It feels good to know that I know what I know now. Schematics that used to confuse me completely are now easy for me to read and interpret. Yes, it is nice to be smarter, and that's probably the most satisfying result of my CIE experience.

Praise for Student Service

"In closing, I'd like to get in a compliment for my Correspondent Counselor who has faithfully seen to it that my supervisor knows I'm studying. I think the monthly reports to my supervisor and generally flattering commentary have been in large part responsible for my pay increases. My Counselor has given me much more student service than "the contract calls for," and I certainly owe him a sincere debt of gratitude.

"And finally, there is Mr. Tom Duffy, my instructor. I don't believe I've ever had the individual attention in any classroom that I've received from Mr. Duffy. He is clear, authoritative, and spared no time or effort to answer my every question. In Mr. Duffy, I've received everything I could have expected from a full-time private tutor.

"I'm very, very satisfied with the whole CIE experience. Every penny I spent for my course was returned many times over, both in increased wages and in personal satisfaction."

Perhaps you too, like Harry Remmert, have realized that to get ahead in Electronics today, you need to know much more than the "screwdriver mechanics." They're limited to "thinking with their hands"... learning by taking things apart and putting them back together... soldering connections, testing circuits, and replacing components. Understandably, their pay is limited—and their future, too.

But for men like Harry Remmert, who have gotten the training they need in the fundamentals of Electronics, there are no such limitations. He was recently promoted, with a good increase in income, to the salaried position of Senior Engineering Assistant working in the design of systems to silence submarines. For trained technicians, the future is bright. Thousands of men will be needed in virtually every field of Electronics from two-way mobile radio to computer testing and troubleshooting.

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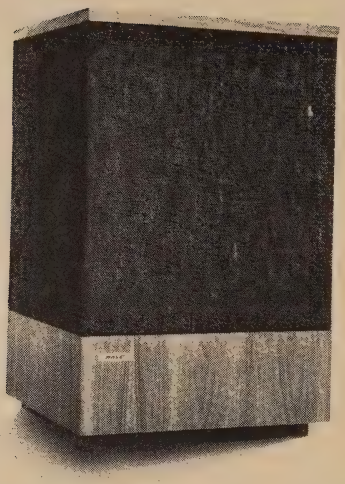

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There is an important reason why we ask you to make this test. There are inherent limitations of performance in the use of a woofer, a tweeter and a crossover—limitations covered in detail in earlier issues. The bypassing of these limitations played a large part in the advances which have made the BOSE 901 the most highly reviewed speaker, regardless of size or price.

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But it became evident that there was no way to keep the advantages of multiple small full-range drivers and equalization. The cost problem was too great. We were forced to accept the woofer-tweeter-crossover combination as the only feasible compromise and set out to achieve the fullest possible realization of this design approach.

Our engineers designed a unique woofer with an unusually long voice coil which provides tight control of bass transients. They developed a new and different approach to crossing over the outputs of the woofer and the two tweeters. In the process they became convinced that in terms of quality of performance there is no acoustical reason to spend more than $125 on any speaker containing woofers, tweeters and crossovers.

The design goal of the 501 was to outperform any other woofer-tweeter-crossover speaker. You be the judge. If we have succeeded, the results will be obvious to you when you make the comparison.

*Literature sent in answer to your request will include a list of franchised BOSE dealers in your area who are capable of demonstrating BOSE speakers to their full performance.

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CIRCLE NO. 8 ON READER SERVICE CARD

News Highlights

Communications Satellite Has Tenth Birthday

Over ten years ago (on July 10, 1962) a small satellite was lifted into space, carrying with it the beginnings of a new era in communications. Dubbed the Telstar satellite, it set the stage for the future by conveying the first television broadcast between the United States and Europe. The historic telecast featured the Stars and Stripes rippling gently in front of the satellite's earth station in Andover, Maine. The inaugural program also included the first telephone call beamed through the satellite. The Telstar project, designed, built and paid for by the Bell System, is credited with making a significant contribution to today's international communications technology. Since Telstar, NASA has launched communications satellites Relay 1 and 2, Syncom 1, 2, and 3, and Intelsat I through IV. The latest communications satellite, launched June 13, can carry 5000 to 6000 two-way telephone conversations and will add 12 TV channels to the 48 now available between the U.S. and other nations. That's 12 to 20 times the capacity of Telstar 1.

RCA Institutes' Course Awarded Degree Status

The N.Y. State Board of Regents has authorized RCA Institutes to confer the degree of Associate in Occupational Studies (AOS) to students completing the school's Electronics Technology Program. This is a 2-year college level engineering technology course which stresses communications and computer technology. After completing the program, a student is qualified as an engineering technician. In addition to the new degree status, the program is accredited by the Engineers' Council for Professional Development. Credit for the course is also given at many colleges and universities.

N.Y. to Replace Fire Boxes with Citizens Alarms

The City of New York has awarded a $5-million contract to North American Philips for expansion of a two-way voice communications system linking the man in the street instantly with either the police or fire departments. Under the contract, 2900 of the new street-corner call boxes and related central equipment will be added to the 200 units the city has tested for the past year. This is the initial step in a planned five-year program to replace all of the city's 15,000 aging fire-alarm boxes with the new citizen's alarm system. The two-way voice communications feature enables the exact location and nature of an emergency to be reported instantly and the appropriate response to be made by the police or fire department.

Color TV Set Sales are Up 21 Percent

U.S. manufacturer sales to dealers of both color and monochrome TV sets were up in the first half of 1972 over sales in the same period in 1971, according to the Electronic Industries Assn. Sales of color TV sets to dealers, the industry's major product, were up 21.1 percent for the first six months. Monochrome TV set sales to dealers were up 9.1 percent over last year. Total TV set sales to dealers were 5,373,-776 units for the first six months, which is up 15.5 percent from last

year. Radio sales to dealers were down 4.2 percent and phonograph sales were down 9.1 percent compared to last year.

More Consumer Demands for Service Technicians

Consumer demands will increasingly focus on the service industry, predicted Garth J. Heisig, director of consumer affairs for the consumer products division of Motorola Inc. He advised TV service technicians at an Atlantic City convention that they should be ready for it. He said there are estimates that within 10 years a family will spend 15 percent or more of its income just for servicing the products it owns.

Electronic Editing at Democratic and Republican Conventions

Editors of United Press International at the Democratic convention are the world's first newsmen to use electronic editing devices to report on-the-spot events. Video display terminals, made by Harris-Intertype, were used to generate and edit convention copy and to monitor the national newswire. Stories were typed on the terminal keyboard at Miami Beach and immediately dispatched to New York. Then information could be held in the computer memory or moved immediately on the newswire to UPI clients. The terminals display 50 lines of text at a time on a CRT screen. As the editor makes corrections, deletions, or additions on the keyboard, lines automatically adjust themselves and revised copy appears instantly. Copy is displayed in upper and lower-case characters, and is easily read in a normally lighted room.

Motorola Versus Learjet on Tape Cartridge Patents

Some months ago, Motorola, one of the pioneers in the early development of cartridge-type magnetic tape players, filed a declaratory judgment action in the Federal District Court in Wilmington, Del., against Gates Learjet Corp. Motorola asked that the court declare four patents owned by Gates Learjet which pertain to the cartridge-type magnetic tape players be declared invalid and non-infringed by Motorola players. A few weeks afterward, Gates Rubber Co., which claims to have obtained title to the Learjet patents, brought a patent infringement suit against Motorola involving the same four patents.

CBS Labs Veep Honored by Audio Group

Ben Bauer, Vice President of the Acoustics and Magnetics Dept. of CBS Labs, has been honored by the Audio Engineering Society. The AES Board of Governors has conferred on him an Honorary Membership for productive innovation and leadership on the frontiers of audio technology. Bauer led the technical team that developed the SQ quadraphonic disc system.

Radiation-Producing Electronic Products Modified by Manufacturers

More than 34,000 radiation-producing electronic products were modified by manufacturers last year as a result of Food and Drug Administration efforts to reduce radiation exposure from electronic equipment. Twenty-two electronic product manufacturers took corrective actions. These actions involved about 15,000 television sets, 35 TV projection devices, 100 TV monitors, 11,000 microwave ovens, 8000 medical diagnostic X-ray machines, and 200 X-ray diffraction and spectrographic units. In addition, four TV receiver manufacturers were involved in compliance actions last year. Tube replacements and improved picture tube shielding corrected the problems in all cases.

The principle is the same. The potential is different.

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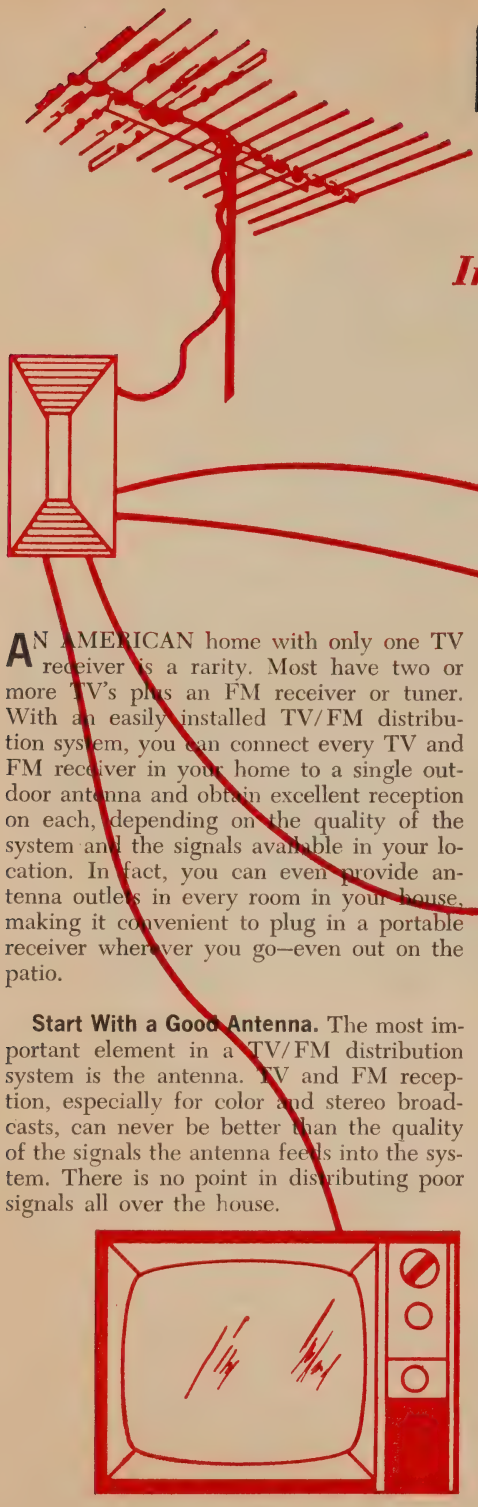
Install a master antenna TV distribution system

BY BERT WOLF, Manager
Jerrold DSD/ECSD Div.



AN AMERICAN home with only one TV receiver is a rarity. Most have two or more TV's plus an FM receiver or tuner. With an easily installed TV/FM distribution system, you can connect every TV and FM receiver in your home to a single outdoor antenna and obtain excellent reception on each, depending on the quality of the system and the signals available in your location. In fact, you can even provide antenna outlets in every room in your house, making it convenient to plug in a portable receiver wherever you go—even out on the patio.

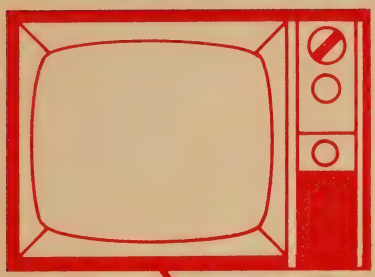
Start With a Good Antenna. The most important element in a TV/FM distribution system is the antenna. TV and FM reception, especially for color and stereo broadcasts, can never be better than the quality of the signals the antenna feeds into the system. There is no point in distributing poor signals all over the house.

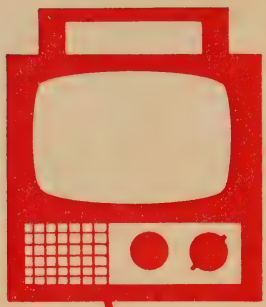
Choose your antenna exactly as you would for a single receiver. (See "Choosing a TV Antenna," March 1972.) Since this antenna will serve a number of receivers, it pays to invest in a better antenna if you have a choice of two or more. Rotators can be used to orient the antenna in different directions to obtain maximum benefit from the antenna. However, the ideal is to be able to view each channel on every TV receiver and listen to each FM station without having to reposition the antenna every time.

In many cases, you can use two or three antennas, pointing in different directions, to circumvent the need for a rotator. Two broadband antennas pointing in different directions can be combined into a single downlead with the aid of a hybrid coupler. But an antenna pointing west may still pick up some signals from the north, and vice versa. The same signal picked up on two different antennas can cause ghosts.

COUPLING SYSTEMS

YOUR TV ANTENNA





In a multi-antenna system, the best bet is to use a yagi coupler to combine a single-channel antenna pointing in one direction with a broadband antenna pointing in another direction. The yagi coupler is frequency selective; one leg passes only the channel to which it is tuned, while the other passes all remaining frequencies. Three single-channel antennas can be combined with a pair of yagi couplers.

If uhf and vhf channels are telecast from different directions in your locale, use separate uhf and vhf antennas, combining them with an appropriate splitter/mixer. Of course, if there are too many different directions with which to contend, the only practical way out is to use a rotator.

If signals need to be boosted, a mast-mounted preamplifier can be used. Such a preamp has a separate power supply whose output is fed up the same transmission line down which the r-f signals are sent to the receivers.

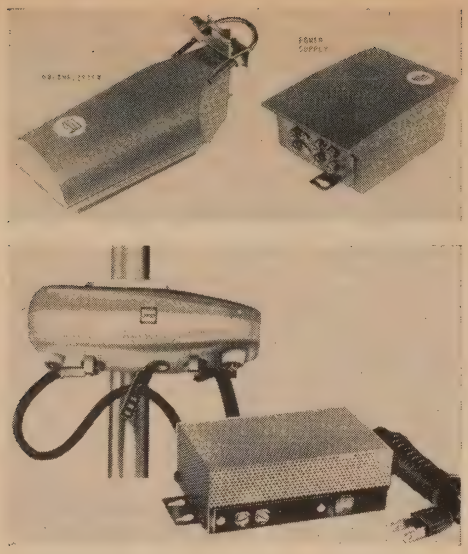
Distributing Signals. Once you have good antenna signals, the next step is to distribute them to the various receivers in your home. You can split the signal into several lines with a multi-set coupler which provides several outputs from a single input.

In strong-signal areas, you can use a passive coupler. However, in weak-signal areas, you will need an amplified coupler to overcome the losses incurred in splitting.

In choosing a coupler there are a few points to keep in mind. Consider which channels your system will carry. Some multi-receiver couplers can handle only vhf channels, while others have the additional capability of accommodating uhf as well. If you are in an area with only vhf channels with no likelihood of a uhf channel getting on the air in the near future, you can forego the uhf capability. Otherwise, choose an all-channel coupler.

The next consideration is the transmission line. Choose one according to your own tastes. Much has been written about the relative merits of both 300-ohm twin-lead and 75-ohm coaxial lines. The 300-ohm twin-lead is generally less expensive and easier to work with, but coax is more durable and much less subject to picking up interference. A good rule-of-thumb is to use coax cable (or shielded twinlead) in areas where ignition and power-line interference is likely to be a problem and conventional twinlead in other areas.

An Outlet In Every Room. If you want a really professional home master antenna TV (MATV) system, you can use a tapoff arrangement to provide a TV/FM outlet in every room in your house. Of course, few people have a TV receiver in every room; but it is nice to be able to use a portable in a child's sickroom, on the patio, or anywhere else.

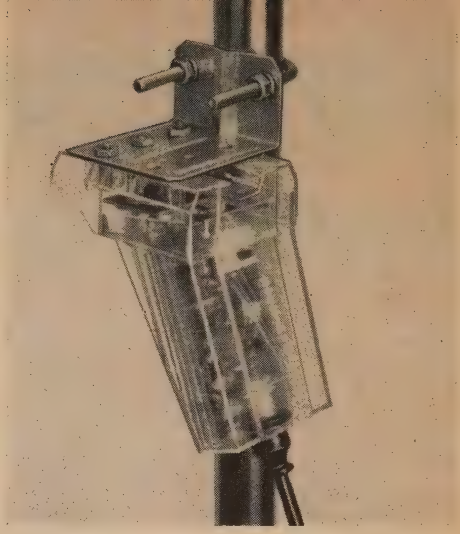


Mast-mounted preamplifiers are shown here along with their power supplies.

A single, high-gain amplifier is used with 75-ohm coax cable. A two-way splitter can be used after the amplifier, and outlets can be made in both branches of the circuit. In each room is a wallplate tapoff, into which can be plugged any TV or FM receiver. The tapoff takes a small amount of signal from the line and isolates each receiver from the others in the system, while maintaining the proper impedance match throughout the system.

To match 75-ohm coax to a 300-ohm TV receiver, you need a matching transformer which can be mounted on the back of the receiver. You do not need a matching transformer for each tapoff, just one for each receiver. If the receiver is portable, attach the transformer and about 6 ft of coax to the antenna terminals on the receiver.

Running Transmission Line. The hardest part of installing a distribution system is the running of transmission line throughout the house. You want to keep the runs hidden as much as possible; but avoid electrical interference by observing these basic precautions; Don't run transmission line close to metal of any kind; metal objects tend to cause interference problems. Use standoffs to keep the twinlead away from the antenna mast, gutters, eaves, and drain pipes. Don't run two or more twinlead cables close together or near electrical wiring. Don't run twinlead close to rotator wires.

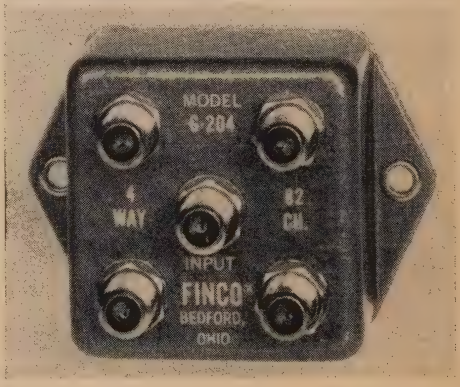


Another housing for mast preamplifier.

Don't crimp standoffs; crimping, in effect, causes short circuits.

Those are the "don't's." Here are equally important "do's." Do support twinlead with standoffs at intervals of 3 to 4 feet (closer, when making bends and turns, to keep it

Passive splitters are available for 2, 3, or 4 sets as well as for conventional twinlead or coaxial cable.



from touching anything—even wood—wherever possible). Do securely attach the twinlead to the antenna terminals and finish by spraying the connections with an acrylic insulator to prevent corrosion. Do make sure that the twinlead goes through the antenna strain relief.

The do's and don't's of coax runs are a bit less demanding: Don't make sharp bends in coax; the bending radius should be at least 4 in. Otherwise, the dielectric can be crushed, causing an impedance mismatch or even a short circuit. Don't make careless connections; a single strand of coax shield touching the center conductor can ruin reception. Don't splice coax; if it needs extending, use a splice connector. Do use silicone grease and a weatherboot to waterproof all outdoor coax connections. Tape the coax securely to the antenna mast. (Unlike twinlead, coax can be run anywhere, even inside metal conduit, without affecting signals.)

Both coax and good-quality twinlead weather quite well. So, it pays to keep most runs outdoors wherever possible. A lead-in wire going down the side of the house is less objectionable and easier to install than the same wire snaking throughout the house. However, eventually the lead-in will have to go indoors.

Your point of entry depends primarily on the placement of the multi-set coupler or amplifier. Once indoors, the line between the antenna and the amplifier should be as short as possible. Of course, the amplifier itself should be located so that you can conveniently run wires to each receiver outlet in your system.

Generally, it is easiest to make your entry through the attic, basement, or under a window. If entry is through masonry, use a power drill equipped with a carbide bit. When entry is made through aluminum siding, drill the hole extra large and wrap the cable with several layers of plastic tape. Entry through wood or asphalt is made easier if a shingle is first removed. Drill your hole, feed in the cable, and replace the shingle.

Amplified splitters for twinlead and coax.

When you get through the exterior wall, you must still penetrate the inside wall. If you have one, use a bit extension; otherwise, use a long ice pick or an awl to put a small hole through the inside wall, just to mark the spot. Then drill from the inside. All entry holes should be angled so that the outside is below the level of the inside hole. Leave enough slack in the cable to let it hang about 3 in. on the outside of the house, and fill the entry hole with caulking or putty. These precautions will provide a waterproof seal and prevent rain damage to walls and siding.

TABLE I—Mast-Mounted Preamplifiers

	Blonder-Tongue		Channel Master		Finney		Jerrold		JFD		Winegard	
	Model	List	Model	List	Model	List	Model	List	Model	List	Model	List
All-Channel												
75 ohm	4552	$62.90	0068	$54.95	G-52	$65.65	4287-S	$53.50	SP2782	$62.50	AC-895B	$48.00
300 ohm*	4542	56.60	0067	49.95	G-50	62.95	4283	43.95	SP2382	58.75	AC-823B	45.95
VHF/FM												
75 ohm	4641	49.30	0041	44.95	G-10	56.70	4207-S	48.50	SP2700	50.00	AC-295B	37.15
300 ohm*	4640	46.10	0031	39.95	M-10	49.95	4214	29.95	SP2300	47.50	AC-223B	35.70
UHF												
75 ohm	4702	54.95			G-30	80.35	4087-S7	59.95			AC-495B	37.90
300 ohm*	4703	52.50	0042	44.95			4083	42.50	SP2314	47.50	AC-423B	36.20
Single-Channel					G-40	103.95	DSS	146.75			AC-2-69	80.65

*In areas with possible powerline or ignition interference, 75-ohm models with coax are recommended.

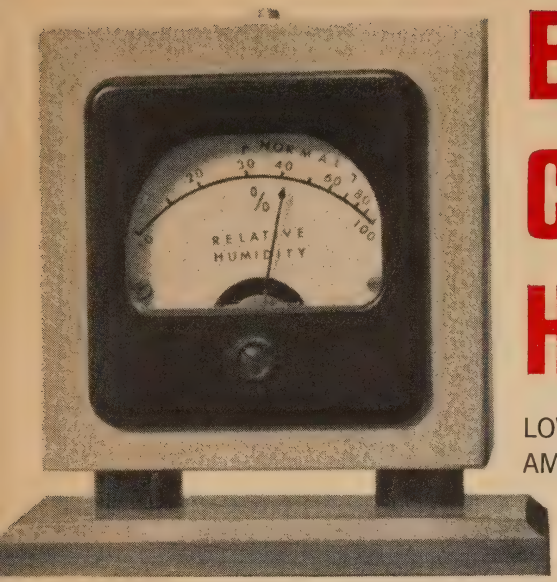
TABLE II—Amplified Couplers

	Blonder-Tongue		Channel Master		Finney		Jerrold		JFD		Winegard	
	Model	List	Model	List	Model	List	Model	List	Model	List	Model	List
4-Set All-Channel												
75 ohms	DA-4U/V-75	$60.40	7336	$49.95	G-923	$46.95	TAC-84	$49.95	PC4782	$47.50	BC-782	$47.80
300 ohms	DA-4U/V-300	54.50	0069	41.50	G-922	43.95	TA-84	40.75	PC4382	42.50	BC-382	43.75
2-Set All-Channel												
300 ohms							TA-82	$21.50			BC-830	20.70
4-Set VHF/FM												
75 ohms	DA-4V-75	40.70	7036	39.95	G-921	39.95	TAC-246	38.50	PC4712	36.25	BC-274	42.45
300 ohms	DA-4V-300	33.50			G-920	33.95	TA-246	32.50	PC4312	30.00	BC-234	41.20
Single 75-ohm All-Channel Output Amplifier for Tap-off System	DA-1U/V-75	52.40	7363	44.95	G-924	45.95	TAC-81	46.50			DA-825	69.00
Complete 4-Set All-Channel Home System			7327	99.95	HWK-75 HWK-300	129.95 89.95	HAS-4	119.50	HS42-75 HS42-300	124.95 89.95		

Once inside the house, try to run the cables through the attic, basement, closets, or crawl spaces. You can snake the cables through walls and ceilings with the aid of electrician's fish tape and long extension bits to drill through studs, but this is very time consuming.

In many cases, lead-in must be exposed. Run it neatly along baseboards. For coax, use round staples, but be careful to avoid crushing the cable. Unfortunately, you will have to use staples to fasten twinlead to baseboards. Be careful not to touch either conductor with a staple. No matter how you position the staples, they will cause some mismatch with twinlead, which can lead to color smears. Just use as few staples as you can get away with, and keep them in the insulation. (Or use double-sided tape between cable and baseboard.) ◈

Some distribution amplifiers have built-in gain controls and traps.



Electro-Chemical Hygrometer

LOW-COST UNIT MEASURES AMBIENT RELATIVE HUMIDITY

BY JOSEPH GIANNELLI

WHEN IT comes to determining how the current weather will affect us, the relative humidity is almost as important as the temperature. (Isn't that why the weather bureau gives us the temperature-humidity index every day?) There are many sophisticated ways of measuring the relative humidity; but if you would like to have your own hygrometer, here's a good direct-reading, fast-responding unit that can be built easily and cheaply.

Many salts, such as common table salt (sodium chloride), are hygroscopic in nature. That is, if the ambient atmosphere has a higher water vapor content (high humidity) than the salt, the salt absorbs the moisture until the vapor pressure of the salt equals the vapor pressure of the atmosphere. At that point the absorption stops, and the salt has some definite ohmic resistance. When the ambient atmosphere drops in humidity, the salt gives up its moisture, and has a higher ohmic resistance.

This change in resistance with humidity can be used in a standard bridge circuit with a meter that is calibrated in percent humidity. However, since salts exhibit some form of polarization to dc current, manifested by a continual resistance change as long as the dc is applied, it is necessary to use ac current in the circuit (see Fig. 1).

Circuit Operation. Transistor *Q1* and its associated components are arranged in a twin-T oscillator configuration. With the values shown in Fig. 1, the frequency is about 400 Hz. The output of the emitter of *Q1* provides the ac signal to the bridge. Power is supplied to the meter during the positive half cycles. The two variable controls (*R5* and *R6*) are used to set the two ends of the meter scale.

Construction. The circuit can be assembled on a small PC board using the foil pattern shown in Fig. 2. The board is mounted directly on the meter terminals through the two holes on top of the board. Large solder lugs are used to make the electrical connections to the meter terminals.

Construction of the sensor is shown in Fig. 3. A ½"-wide strip of fiberglass cloth (about the same weight as a handkerchief) is mounted as shown. After clamping both ends in the brass plates, the weave threads are removed from the cloth to improve the response time. The completed sensor is dipped into a solution of lithium chloride (a mound of the salt about the size of a dime dissolved in a tablespoon of water). After soaking the sensor, shake off the excess solution and allow the sensor to dry.

Calibration and Test. When assembly is complete and the sensor is dry, attach about 8 inches of insulated wire to each end of the sensor, connect it to the circuit, and suspend the sensor in an 8-ounce jar contain-

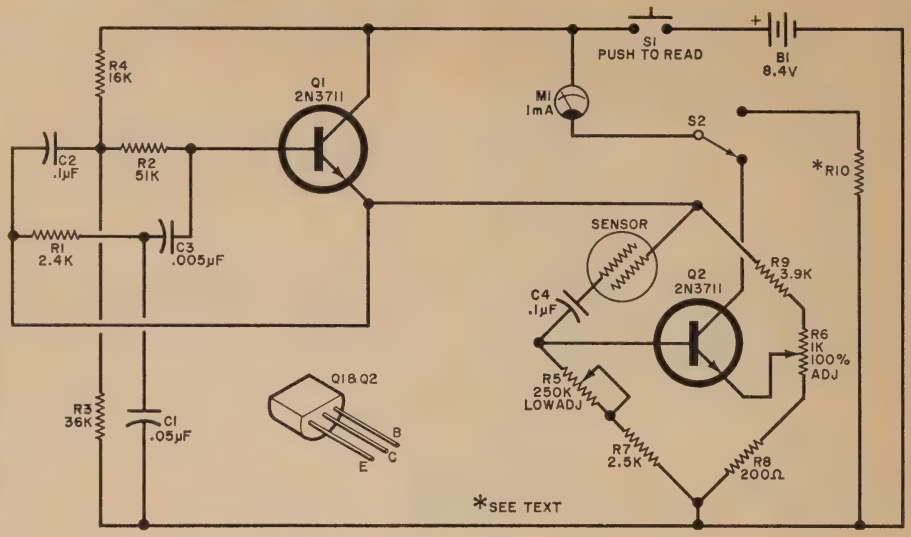


Fig. 1. Twin-T oscillator circuit (Q1) provides the depolarization current for the humidity sensor which is one leg of a bridge circuit, with meter driver Q2.

PARTS LIST

B1—4.2-volt mercury battery (2 required) (Mallory TRI 33 or similar)
C1—0.05-μF Mylar capacitor
C2, C4—0.1-μF Mylar capacitor
C3—0.005-μF Mylar capacitor
M1—1-mA (or less) meter
Q1, Q2—2N3711 or 2N3392 transistor
R1—2400-ohm resistor
R2—51,000-ohm resistor
R3—36,000-ohm resistor
R4—16,000-ohm resistor
R5—250,000-ohm, PC-type potentiometer
R6—1000-ohm, PC-type potentiometer
R7—2500-ohm resistor
R8—200-ohm resistor
R9—3900-ohm resistor
R10—(see text)
S1—Normally open pushbutton switch
S2—Spdt slide switch
Misc.—Battery holder, 25,000-ohm potentiometer for 100% check, suitable chassis, fiberglass cloth (handkerchief weight), lithium chloride (1 oz, available at chemical supply houses or Conso-Lab Supply Co., 7 Endo Blvd., Garden City, NY 11533), hardware for sensor, mounting hardware, etc.

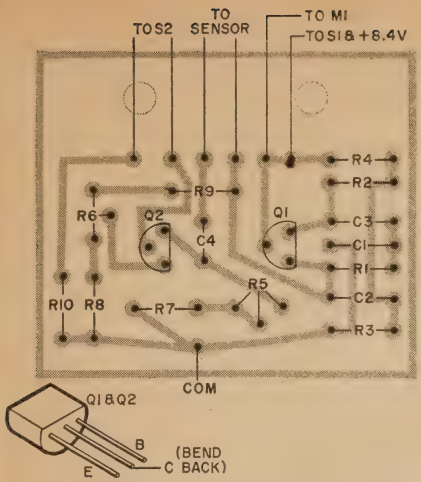
ing a wad of water-soaked tissue. Do not allow the sensor to touch the wet tissue. The sensor leads can be brought out under the jar lid. After a few minutes, place *S2* in the bridge position, depress pushbutton *S1*, and adjust *R6* to obtain a 100% indication on the meter scale. When you are satisfied that the reading repeats after a few more minutes, remove the sensor from the jar, disconnect it from the circuit, and substitute a 25,000-ohm potentiometer for the sensor. Adjust this potentiometer to obtain a 100% indication on the meter. Dry the sensor by placing it in the air stream from a fan.

Without disturbing the setting of the 25,000-ohm 100% humidity potentiometer, remove it from the circuit (for use in later checks), and re-connect the dried sensor.

To determine the local ambient humidity, use a conventional bulb thermometer to record the temperature. Then wrap the bulb with water-soaked tissue and place it in the

PSYCHROMETRY TABLE

Percent Humidity	Dry Bulb	Wet Bulb	Dry Bulb	Wet Bulb	Dry Bulb	Wet Bulb
10	75	50	70	47	65	44
20		53		50		47
30		56.5		53		48.5
40		60		56		52
50		62.5		58		54
60		65		61		56.5
70		68		63		59
80		70		65.5		61
90		72.5		68		63



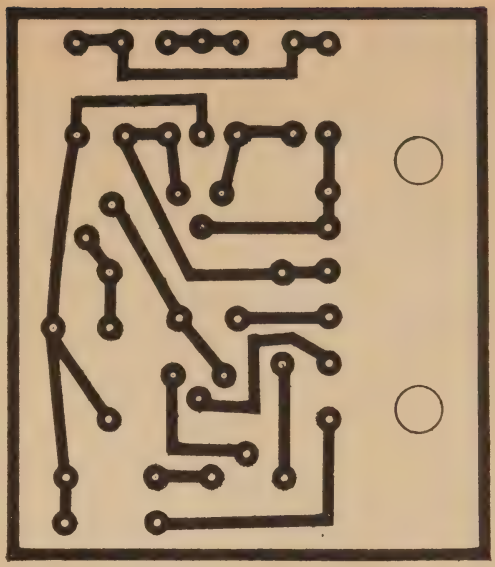
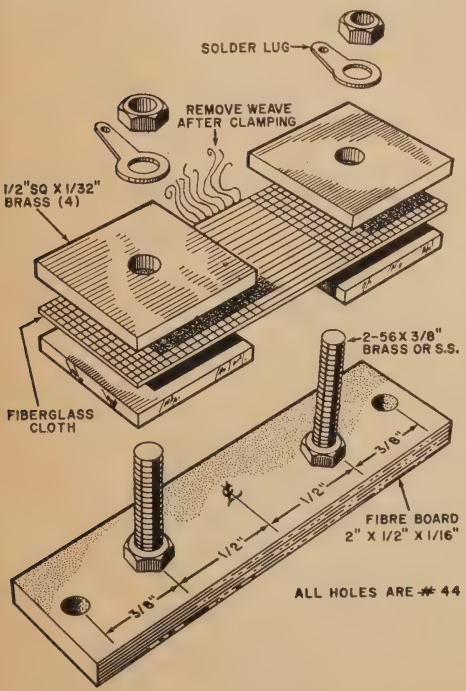


Fig. 2. Foil pattern (right) and component layout (above). The board is mounted right on the meter terminals.

air stream from a fan. Record the lower temperature. The accompanying table is a greatly simplified psychrometric table that relates dry-bulb temperatures to wet-bulb temperatures and converts the two readings to percent humidity. A more detailed psychrometric chart can be found in almost any book on air conditioning in your local library.

Fig. 3. Sensor is a small piece of ½" fiberglass with some weave removed.



After a short period of time, the sensor will have taken on the local humidity and potentiometer *R5* can be adjusted so that the meter reads the same as the humidity determined from the dry and wet thermometer readings. Using the previously set 25,000-ohm potentiometer in place of the sensor, recheck the 100% point and adjust *R6* if necessary. Recheck the local humidity and adjust *R5* again if necessary. The two potentiometers (*R5* and *R6*) are set to obtain the best compromise. The two calibrated points will repeat accurately at room temperatures between 68° and 78°F, but will be off by about 10% at other temperatures. If you require better accuracy, many wet/dry-bulb readings may be made at different times, with required corrections noted. Then a new meter scale can be fabricated.

An increase in humidity will require about ½ to 1 second to register, but a decrease will require about 3 minutes to register.

Resistor *R10* is used to keep tabs on the battery. Use a value that will produce about a ¾-scale indication on the meter, with a new battery and *S2* in the battery test position. Mark this point on the meter scale. Typical values for *R10* are 11,000 ohms for a 1-mA meter movement and 22,000 ohms for a 0.5-mA meter. ◈

BUILD A ZENER DIODE SUBSTITUTION BOX

SIMULATES A ZENER DIODE FROM 1.2 TO 18 VOLTS WITH POWER DISSIPATION TO SIX WATTS

BY STANLEY SULA

MOST experimenters are aware of the zener diode's usefulness and versatility. However, the fact that a single zener diode can provide only one value of zener voltage is a characteristic which may discourage experimentation with this very useful device. The trouble of buying a new diode every time a different voltage is required in an experimental circuit can be quite expensive and frustrating.

The Zener Diode Substitution Box described here is a very worthwhile project for those who experiment with circuits involving zener diodes. The substitution box provides a continuously variable zener breakdown from approximately 1.2 to 18 volts, with a power dissipation of up to six watts. Using all new parts, it can be constructed easily for less than $10. The device's electrical characteristics are identical to those of a high-quality zener diode.

Construction. Due to the simplicity of the circuit (Fig. 1), point-to-point wiring can be used. Parts layout is not critical. The maximum power dissipation of the circuit varies from ½ watt to 6 watts, depending on whether or not *Q1* is provided with a heat sink. With no heat sink, maximum dissipation is approximately ½ watt. With a "slip-on" fin-type heat sink, dissipation is about 1 watt; and for six watts, a heavy-duty heat sink is necessary.

If power dissipation is to be no more than 1 watt, the unit can be built in a 4" × 2⅞" × 1½" plastic enclosure. For a higher dissipation, a larger enclosure will be required.

Do not use a carbon-composition potentiometer for *R2*. Even the so-called "linear taper" potentiometers of this type can be grossly nonlinear and their use can lead to a very nonlinear voltage scale. For reasonable linearity at low cost, a wirewound pot must be used. For a small enclosure, be sure to use the miniature VW-type Mallory potentiometer given in the Parts List to leave enough room for the battery.

Theory of Operation. The circuit is a high-gain Darlington amplifier, with a negative bias supply which normally keeps the transistors in their nonconducting state. The bias is varied by *R2* from 1.2 to 18 volts. Note that one end of the bias supply (the wiper arm of *R2*) is connected to *Q2*'s base, while the other end is connected to one of the input terminals. Thus, the voltage across the input terminals is bucked by the bias voltage so that, as long as the bias exceeds the input, the net voltage on *Q2* is negative and the transistors do not conduct. However, as soon as the positive input exceeds the negative bias by 1.2 volts, the transistors turn on and present a very low resistance between the input terminals.

Transistors *Q1* and *Q2* will not conduct until a positive voltage of 0.6 appears across each of their emitter-base junctions. This sets the minimum of 1.2 volts for the lowest zener voltage attainable with this circuit.

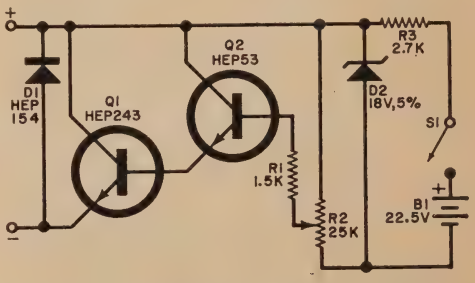


Fig. 1. Darlington amplifier switches on when voltage at the input bucks out preset bias. With proper heat sink on Q1, dissipation can be 6 watts.

PARTS LIST

B1—22½-volt battery (Eveready #412)
D1—1-A, 50-volt diode (HEP154)
D2—18-volt zener diode (HEPZ2522)
Q1—Transistor (HEP243)
Q2—Transistor (HEP53)
R1—1500-ohm, ½-watt resistor
R2—25,000-ohm, 5-watt wirewound potentiometer (Mallory VW-25K)
R3—2700-ohm, ½-watt resistor
S1—Spst slide switch
Misc.—Enclosure, 5-lug terminal strip, heat sink (see text), knob, battery holder (Keystone #177), hardware, etc.

Diode *D1* simulates the forward characteristics of a zener diode and also protects *Q1* and *Q2* from reverse polarity voltages.

Calibration. The calibration circuit is shown in Fig. 2. The voltmeter should be capable of measuring down to one volt accurately. Turn the voltage-selector dial (*R2*) on the substitution box fully clockwise (minimum resistance). This should give a meter reading close to 1.2 volts. Slowly turn the dial until the meter reads 2 volts. Make a graduation mark on the dial at this point. Continue rotating the dial until the meter indicates 3 volts and make another dial marking. Continue until you reach the highest attainable voltage. This maximum voltage will be between 18 and 20 volts, depending on the exact value of *D2*. To complete the dial marking at the lower end, make a mark for 1 volt a distance below 2 volts that is approximately the average of the distance between other voltage markings.

Operation. Since the circuit of the substitution box duplicates the characteristics of a zener diode so closely, it is used exactly as you would use a regular zener diode. As

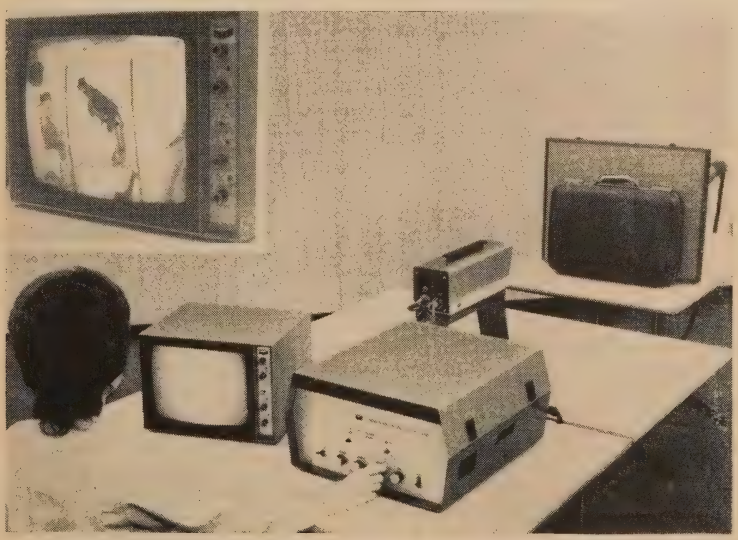
Fig. 2. To calibrate the dial on R2, use dc voltmeter capable of indicating down to about 1 volt accurately.

with any such diode, when connecting it into a circuit, always be sure that there is sufficient series resistance to prevent exceeding the power dissipation limits. This minimum series resistance can be calculated from the formula $R=E_zE_d/P$, where R is the minimum series resistance, E_z is the zener voltage, E_d is the difference between the zener voltage and the source voltage, and P is the maximum power dissipation in watts.

Needless to say, switch *S1* should be turned off when the unit is not in use, though the battery drain is only about 2.5 mA. Incidentally, with *S1* turned off, the device acts as a 1.2-volt zener regardless of the setting of the voltage dial. However, the zener voltage knee in this case is not as abrupt as it is with the switch on and the voltage dial set to 1.2 volts. ◈

LUGGAGE INSPECTION SYSTEM

A system that uses a low-dose, short-pulse X ray to detect illegal guns, explosives, etc. in airplane luggage has been developed by the Bendix Corporation's Aerospace Systems Div. The portable Bendix-Ray Inspection System is easily operated by one person. An example of baggage contents can be seen on the video monitor at upper left.



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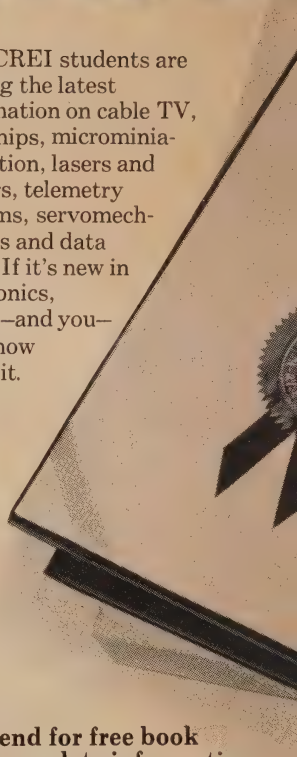

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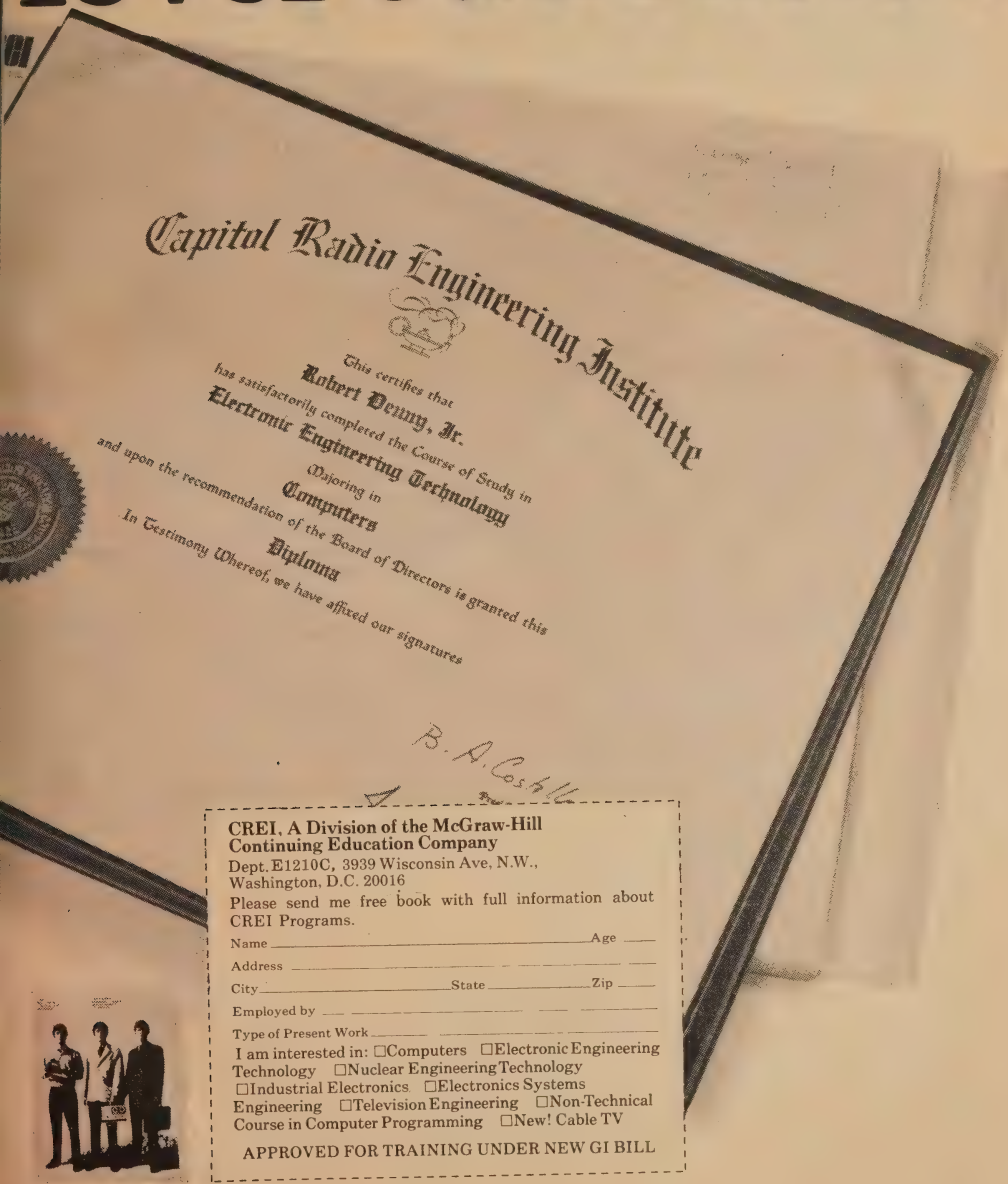
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APPROVED FOR TRAINING UNDER NEW GI BILL

AN ACOUSTIC MICROSCOPE

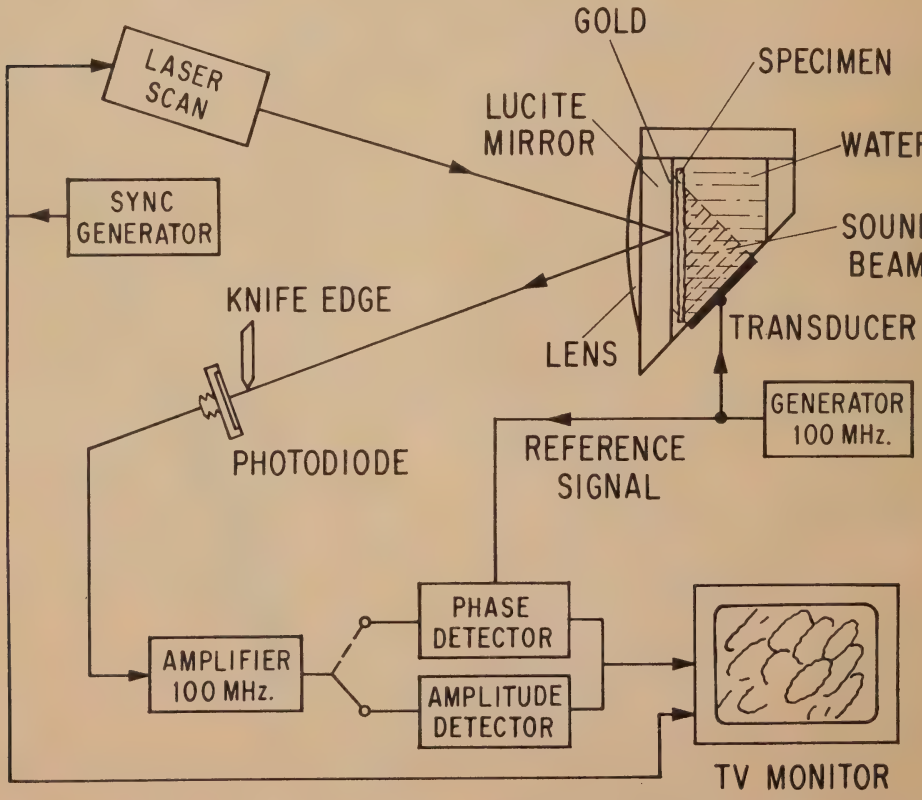
USES ULTRASONIC WAVES AND LASER HOLOGRAM

A NEW concept in microscopes, using high-frequency sound waves rather than light has been developed by Zenith Radio Corp.

A biological specimen is immersed in water and a 100-MHz ultrasonic wave is sent through it (see drawing). The wave, carrying spatial information about the specimen, strikes a plastic mirror causing a minute ripple pattern to appear (dynamic acoustic hologram). At the same time, a focused laser beam scans the selected area of the mirror by means of two acousto-optic cells, synchronized to a TV monitor. The ripples on the mirror surface cause periodic angular deflection of the laser beam; and, after being picked up by a photodiode, this signal is converted into an acoustic hologram and displayed on the TV monitor.

The sound frequency now used is 100 MHz. At this frequency, the smallest detail resolvable is about one thousandth of an inch. It is hoped to improve the resolution by using ultrasonic frequencies as high as 50 times greater so that the resolving power of the acoustic microscope would be the same as that of a conventional optical device.

However, resolution is not the most important feature. Because sound is a mechanical wave motion, while light is not, an acoustic microscope can show details which may go undetected in an optical microscope. This could be very important in cell tissue studies since living specimens can be observed. ◈



BY MORTIMER S. SUMBERG

PA SOUND SYSTEMS

ANSWERS TO YOUR QUERIES ABOUT PUBLIC ADDRESS SYSTEMS

AS IS true of every other trade in electronics, professional public address (PA) system installers have evolved various techniques to get their jobs done. Fortunately, anyone who is new to PA installation work has ready access to most of the basic techniques—always assuming that he has made the acquaintance of a long-time installer or has access to an excellent book or two. For those who do not have this edge, this article deals with ten of the most important technical aspects of PA system installation and equipment, presented at a level within easy grasp of beginners. Aside from hints on how to place and aim speakers and microphones, no discussion of the mechanics of stringing cables, placing the amplifier, etc., are given. These things depend on the location of the installation, the architecture to be dealt with, and so forth—things which are not beyond the abilities of most people to comprehend.

1. How much audio power is needed?

The exact amount of power required can be accurately determined by trial and error or by using a sound level meter to measure ambient noise levels. A simple setup would consist of a 20-watt audio amplifier and a loudspeaker mounted atop a ladder. The amplifier's volume control can be advanced until the speaker produces the desired sound level. Then, using a voltmeter and the formula $P=E^2/Z$, the power in watts fed to the speaker under these conditions can be calculated.

Be conservative in computing amplifier power to insure against errors in judgement, permit higher sound levels for overflow crowds and areas with high noise levels, and allow for future expansion of the system. The reserve power also insures against distortion on peaks when the amplifier is operated at high power levels.

Do not let amplifier costs intimidate you into underpowering an installation. The cost-per-watt of output power is considerably less in high-power amplifiers than it is in low-power amplifiers. A typical 60-watt amplifier is usually only 20 percent more expensive than a 30-watt amplifier with identical features.

Human hearing responds logarithmically to increases in sound levels. Bear in mind, then, that doubling output power is only slightly noticeable. Hence, it makes no sense to substitute a 40-watt amplifier for an inadequate 30-watt amplifier. If more power is needed, go to a 60-watt (or higher) amplifier.

The factors which have the greatest influence on the total power required of an amplifier include the size of the area to be covered, ambient noise level, speaker efficiency, acoustic conditions, and size and location of the audience. (Less experienced

installers can refer to Table I to determine roughly how much power is required for a variety of installations.)

The power an amplifier must provide in a given system depends on the number of speakers it is to drive and the levels at which each is to be driven. A system employing ten speakers, each to be driven at 5 watts, requires a 50-watt amplifier.

2. How many speakers should be used?

This depends, in part, on the types of speakers being used. A reentrant horn in a factory or warehouse will usually cover a 50′ × 40′ area if driven at 3 to 5 watts. An 8-in. cone-type speaker mounted in an 8-ft high ceiling will cover about 225 sq ft with 0.5 to 1 watt of driving power; in a 15-ft high ceiling, coverage will be about 400 sq ft for a 1-watt driving level (see Table II).

The average cone speaker has an efficiency of 2 to 5 percent, while reentrant horns score about 15 percent. So, for any given area, horns require a great deal less power than do cone speakers to provide the same loudness levels.

3. What types of speakers?

There are five basic categories of installation environments for PA systems. To adequately answer this question, we will discuss each category separately.

Churches: The type of speaker configurations commonly used include sound columns, baffled wall speakers, and ceiling mounted speakers.

Sound columns are the simplest to install and the most effective in maintaining the illusion of sound coming directly from the pulpit. Uniform sound quality and coverage, high speech intelligibility, and the absence of "blasting" characterize sound columns. Mount them on both sides of the pulpit at the front of the church. The bottoms should be at least 6 ft above floor level with the columns tilted slightly toward the floor so that their axes intersect the last row of seats.

A typical cardioid dynamic microphone for professional applications that require a sharp directional pattern.

Table I—Amplifier Power Ratings for Various Installations

Installation	Dimensions	Amplifier Rating (Watts)
Church	Small	10-20
Church	Large	30-60
Auditorium	High School	30-60
Factory (Quiet)	100 x 200′ x 20′	30
Factory (Noisy)	100′ x 200′ x 20′	60-100
Athletic Field	High School	50-100
Office (Quiet)	100′ x 50′ x 10′	10
Office (Noisy)	100′ x 50′ x 10′	20
Classroom	30′ x 30′ x 10′	0.5

Wall baffles housing 8-in. or 12-in. cone-type speakers are preferred where interior architecture or altar design makes impractical the installation of columns. Mount them 7-12 ft above floor level and 15-20 ft apart along both sides of the church. The pair closest to the pulpit should be about 15 ft forward of the microphone to reduce the possibility of feedback.

Flush-mounted ceiling speakers are frequently used in new construction where ceilings are relatively low. This arrangement provides excellent low-level sound dispersion and is very attractive in appearance. It normally requires more installation labor than the other two system configurations.

Factories: High speech intelligibility and low reverberation are musts. This can be accomplished with small reentrant horns spaced 40-50 ft apart. Complete coverage is not always required since it is usually sufficient to cover only working areas, aisles, and corridors. Private offices need not have speakers since sound usually spills over into them from the corridors. Except in unusually noisy factories, six horns will provide good coverage over an area of 15,000-20,000 sq ft.

If the width of the factory is greater than 60 ft, use at least two rows of horns. Start the first row 20 ft from a side wall; the second row 40-50 ft from the first. Mount the horns 8-15 ft above the floor, preferably with all of them facing in the same direction and tilted downward to keep the sound

from reflecting off the far wall to reduce reverberation.

Athletic Fields: The simplest and best arrangement consists of four high-efficiency horns mounted above the pressbox or the scoreboard (on the 50-yard line). The horns should be aimed to provide even coverage of the opposite stands. Each of the four horns should be driven by 20 watts of power. Echo effects are minimized because the sound originates from a single source, nor will the horns blast spectators directly in front and below them.

Restaurants: Ceiling speakers are preferred here because they assure excellent coverage without blasting and are the most attractive. (Use the data in Table II for determining spacing.) If wall-mounted 8-in. cone speakers in wood baffles are preferred, install them on two opposing walls 7-8 ft above the floor (regardless of ceiling height) and about 15-20 ft apart. The end speakers can be located 10 ft in from the corners. In quiet restaurants, plan on 0.5-1 watt of power per speaker; in noisy restaurants, up this figure to 2 watts per speaker.

Table II—Number of Ceiling Speakers Required for Different Ceiling Heights*

Area (sq ft)	Ceiling Height (ft)		
	8 or less (Note 1)	9 to 15 (Note 2)	16 to 35 (Note 3)
250	1	1	1
500	2	2	1
650	3	2	1
900	3	2	1
1000	4	3	2
1500	7	4	2
2000	10	5	3
4000	18	10	5

*Speakers are driven to ½ watt in quiet public room and 2 watts in a noisy location.
Notes:
1. Speaker covers approximately 225 sq ft. Spacing is 15 ft.
2. Speaker covers approximately 400 sq ft. Spacing is 20 ft.
3. Speaker covers approximately 900 sq ft. Spacing is 30 ft.

Offices: Install ceiling or wall-mounted speakers, using the same spacing and input power recommended for restaurants. A single wall speaker will usually be adequate for a 30′ by 20′ room.

4. What is impedance matching?

An amplifier delivers its full rated power with minimum distortion into its speaker load only when load and amplifier output impedances are the same. Most PA amplifier outputs are terminal strips with the screw taps marked C (common); 4, 8, and 16 (ohms); and 25 V and 70 V. The 4-, 8-, and 16-ohm taps permit direct connection of one or a limited number of speakers. The 25- and 70-volt taps are convenient outputs for very long speaker lines which must be terminated by constant-voltage line-matching transformers attached to cone-type speakers or integrated into horn drivers. If the mismatch between amplifier and load is excessive, the amplifier will not deliver its full rated output power, frequency response will deteriorate, and the useful lives of output tubes and transistors will be shortened.

5. Why line-matching transformers?

Line-matching transformers at each speaker in a multi-speaker system minimize power losses in the feed lines (by operating at the relatively high 25- or 70-volt amplifier output). If the 4-, 8-, or 16-ohm outputs were used, the lines would have to be short or be made from extra heavy duty cables to avoid excessive power losses.

Perhaps of more importance is the ease with which line-matching transformers permit the installer to distribute varying power levels to the different speakers in the system. In a typical factory system, for example, it is relatively simple to drive each office speaker at 0.5 watt, corridor speakers at 1 watt each, and production area horns at 5 watts each.

6. What is meant by phasing?

Phasing refers to the manner in which two or more speakers are wired into a system to avoid cancellations and resultant dead spots. Speakers facing in the same direction are in phase when their cones move in a common direction when the same driving signal is applied simultaneously to both speakers. Proper phasing can be accomplished with similar speakers from the same manufacturer by connecting together the coded terminals on the speakers.

If the speakers face each other, correct phasing is obtained when one cone moves outward and the other inward with the same signal applied to both speakers simultaneously. This is done by transposing one set of speaker connections.

Phasing is of no great concern when speakers are widely separated or pointing in opposite directions. In fact, out-of-phase

connections will sometimes reduce reverberation problems.

Microphone phasing is frequently overlooked by installers who are unaware that it is often more important than is speaker phasing. When speakers are out of phase, dead spots occur in certain areas. But when microphones are out of phase, listening is difficult everywhere. Mikes must be properly phased if they are within range of a common sound source and are connected to the same amplifier. This is accomplished by the simple expedient of wiring cables to connectors in identical manner (shield to pin 1, black wire to pin 2, red wire to pin 3).

7. High- or low-impedance microphones?

High-impedance (Hi-Z) microphones are limited to use with cables not exceeding 25 ft in length. Longer cables cause loss of power, degrading the signal-to-noise ratio, and the loss of high frequencies. Too, fluorescent lighting, broadcast stations, and other sources of interference are much more likely to be picked up by Hi-Z mike cable.

Low-impedance (Lo-Z) microphones (150-200 ohms), on the other hand, can be used when several hundred feet separate mike and amplifier with no losses in frequency response or signal level. If you plan to use Lo-Z mikes, make certain that the amplifier has a matching Lo-Z input. For minimum pickup of hum and noise, use a balanced mike line with an input transformer in the amplifier.

Problems occur when impedance mismatches are made between mike and amplifier. A Hi-Z mike plugged into a Lo-Z input produces a serious dropoff in low frequencies. A Lo-Z mike connected to a Hi-Z input usually results in a 20-dB loss in level.

8. Cardioids or omnidirectional mikes?

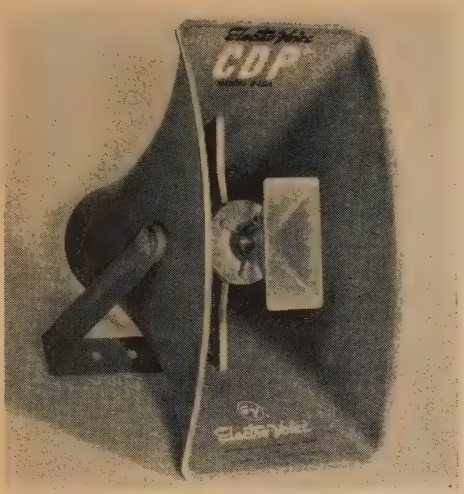
An omnidirectional mike is sensitive to sound coming from all directions. A cardioid mike has high input sensitivity and excellent pickup in only the forward direction, rejecting or reducing sounds originating from the sides and rear. Where an omnidirectional mike can be used, it generally has a smoother frequency response than a comparably priced cardioid and is generally less susceptible to breath popping and mechanical shock.

For most PA systems, however, the cardioid mike is a must. Because of its heart-shaped forward pickup pattern and ability to reject sounds coming from the sides and rear, the cardioid considerably increases the working distance between it and the signal source before reverberation becomes annoying. Random background noises are also greatly reduced and feedback is minimized.

9. How is feedback minimized?

In the main, this question has already been answered: use cardioid mikes, sound columns oriented to minimize rear-wall reflections, reentrant horns angled down and away from the mike, and wall speakers well forward of the mike. But there is more that can be done in severe cases.

This example of deluxe public address amplifier (with speech and notch filters) has monitor speaker and sound level meter, right, individual gain and filter controls, left.



PA loudspeaker that has two diffraction horns, one for the treble frequencies and the other for midrange and bass. It has wide-angle horizontal dispersion when mounted as shown.

Deluxe amplifiers offer speech and notch filters which materially help to reject the portions of the audio spectrum which aggravate feedback. A recently developed line of amplifiers provides equalizer filter controls which permit boosting or cutting selected frequencies (80, 300, 1000, 5000, and 9000 Hz) to suit room acoustics and minimize feedback. If the problem persists, a supercardioid mike with a very narrow forward pickup angle or a 3-position switch which attenuates troublesome low frequencies by up to 10 dB can be tried.

Good lapel mikes are highly effective in reducing feedback because the speaker is ideally located with respect to the mike. The close direct sound from his voice overrides the reflected sounds. A level increase of as much as 6 dB is possible before feedback occurs.

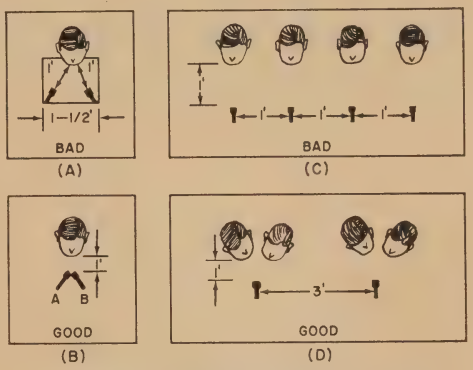
Because feedback "seizes" on the peaks of a mike's irregular response, the mike may very well be the most important component in a PA system. Consequently, it is good practice to buy the best microphone your budget permits.

10. How should microphones be placed?

This is one of the most important but least frequently asked questions about PA systems. In answer, briefly, here are a few techniques you should employ:

Lecterns: Use a single mike in front of the lecturer. With a mike on either side of the speaker as shown at (A) in the diagram, acoustic phase cancellation results whenever the speaker moves away from dead center. This is caused by sound reaching one mike before it reaches the other, effectively distorting the response curves of both. If two mikes must be used, they should be spaced apart and angled toward each other so that the pickup ends are nose to nose and only ½ in. apart as in (B). With this setup, sound reaches both mikes at almost the same time even if the speaker moves far off dead center.

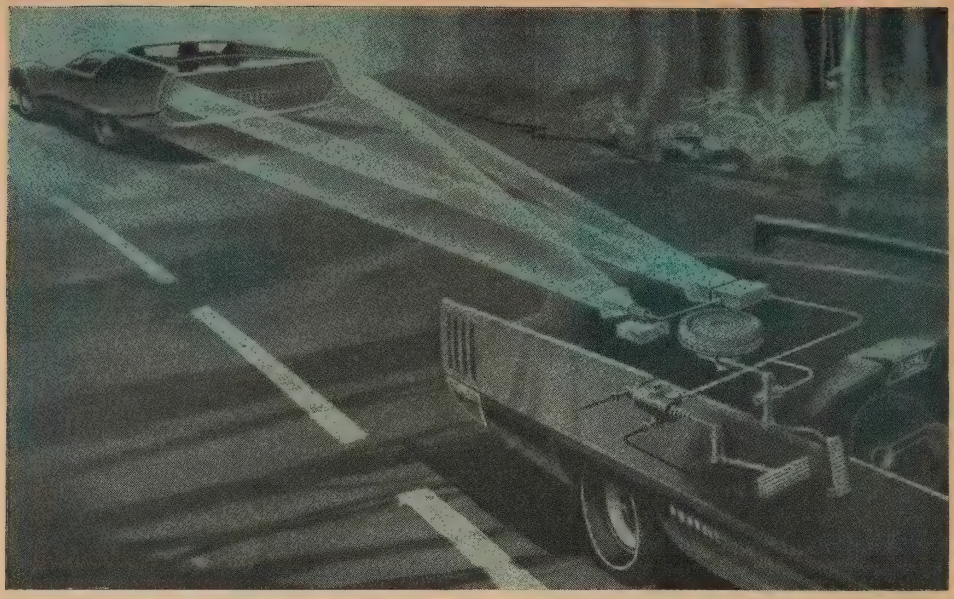
Stage: Use the fewest mikes you can get away with. Space them evenly across the stage and as far apart as possible. Install the mikes on 6-in. high stands, place them on the stage and tilt the mikes downward at 45° angles so that the pickup ends are 1 in. or less above the floor. In addition to



Examples of good and bad microphone placement for single speaker or group.

achieving an excellent frequency response, the mikes will effectively exhibit a gain of 6-12 dB. (Note: Never angle the mikes upward; this seriously distorts their frequency response curves.)

Singing Groups: Avoid spacing mikes 1 ft apart as shown in (C). Instead, space them at least three times as far apart as any mike is from a singer as in (D). When two mikes must be used in close proximity, interference can be reduced by angling cardioid mikes away from each other. A still better arrangement is shown in (B) with singers on the right picked up by mike A and singers on the left by mike B with no acoustic cancellation. ◈



Anti-Collision Systems for Autos

MANY PEOPLE ARE WORKING ON WAYS TO PREVENT ACCIDENTS

BY FRED W. HOLDER

AUTOMATIC speed control systems have been available as options on many American cars for several years now. These systems permit a car to hold any selected speed without driver control of the throttle. For drivers on the open road, they have been a desirable convenience. However, when moderate to heavy traffic is encountered, their convenience becomes marginal because the driver is constantly forced to override the system to prevent collisions. Thus, with the addition of a system to automatically slow down or speed up the vehicle to meet changing traffic conditions, automatic speed control becomes an even more desirable—and practical—feature. Add automatic braking when the distance separating two moving vehicles becomes critical, and you have a real safety device.

Bendix, Ford, Sylvania, and others are working on systems which will refuse to let your car ram another vehicle or will sound a warning if you are about to back over something you cannot see. These systems are still in the development stages, but they are expected to debut by the mid-1970's.

According to William Miron, Bendix Automotive Group President, the Bendix Adaptive Speed Control (ASC) system has been under development for about 15 years. He estimates that ASC will appear as an option in 1974 or 1975 (possibly earlier) cars. Estimates show that this system will cost less than $200, a small price to pay for safety.

In addition to headway protection, warning systems are also under way to cover the "back field." If you have ever backed over your kid's bike, you will appreciate the extra feeling of safety that one of these back-up systems can give you.

The Bendix systems employ a radar beam as the detecting medium, while Ford has opted for infrared radiation. Both, however, project an invisible beam forward or backward to detect objects in the path of the vehicle. In the case of forward movement, they apply brake or accelerator to maintain a specified safe distance ahead of the car. Neither system requires the other object or vehicle to be equipped with a responding device.

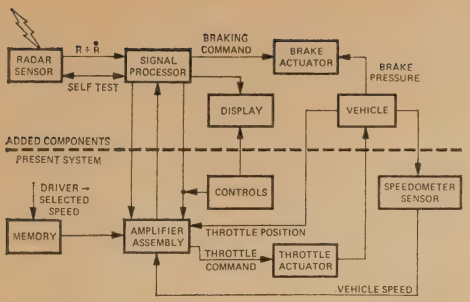


Fig. 1. Bendix adaptive speed control system includes ranging and braking.

Headway Control. The Bendix ASC system is an extension of their electronic automatic speed control system. In Fig. 1, the components below the dashed line comprise the basic speed control system. Those above the line provide automatic headway control. The driver actuates the system by pushing a speed-set button. The system memorizes the speed selected and signals the throttle actuator to maintain this speed. If changing road grade causes speed errors, the throttle is automatically adjusted to correct speed.

If another vehicle is overtaken, the radar measures the relative velocity and range and sends them to the signal processor. The signal processor combines this data with an input of the equipped car's speed and determines whether the throttle or brakes should be applied to maintain a safe distance behind the other vehicle.

The equipped vehicle will continue to follow the lead car as long as it stays under the driver-set speed. The system will never exceed the driver-set speed. However, the driver can override the system at any time by manually applying the throttle or brakes. If a car cuts in front of the equipped vehicle, its speed will be decreased or the brakes will be applied to prevent a collision.

One of the problems encountered while developing the Bendix system was the design of a low-cost radar suitable for automobile headway control. Because both range and range rate were needed, a two-frequency CW approach was selected (see Fig. 2). The transmitter is switched between two closely spaced frequencies, and the doppler-shifted return signals are gated into separate channels. The range is then a function of the relative phase between the two doppler signals. It is extracted by a phase detector.

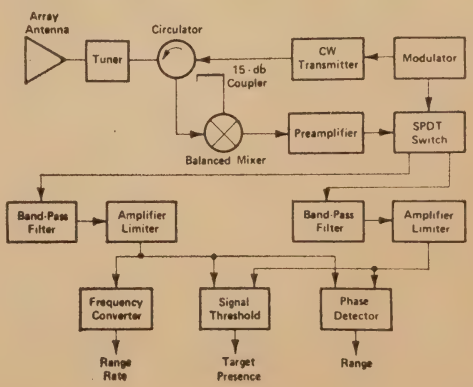
The range rate is determined from one of the doppler channels. A third output was needed to ensure that the processor would accept only data with good signal-to-noise ratio level. This output, the threshold level, determines the maximum range of the system.

In his paper "Application of Radar to Automobile Control and Sensing," W. P. Harokopus of Bendix stated that he encountered two systems problems from the use of a two-frequency radar. First, because doppler shift is required to obtain range, range information is not available when the range rate is reduced to zero. Second, the system lacks range resolution and can suffer from multiple target effects. He went on to explain, however, that experience with the system to date indicates that, by providing the signal processor with memory and smoothing, these obstacles are overcome.

The first Bendix radar provided an operating range of 200-400 ft, depending on the size and shape of the car involved. Small foreign cars are at the low end of the range. This radar operates at 16 GHz with 50 mW of transmitter power. It uses a standing-wave waveguide array antenna in place of the car's grille. The other antenna components are standard microwave packages including a circulator, mixer, coupler, and isolator. The transmitter is a Gunn oscillator.

Bendix is devoting a considerable amount of their development work to ensuring that the best fail-safe approach is selected for the production system. Their radar has a self-test feature which, in the absence of a target, causes the modulator to periodically audio modulate the oscillator. The system detects this modulation through leakage.

Fig. 2. Diagram of Bendix radar system.



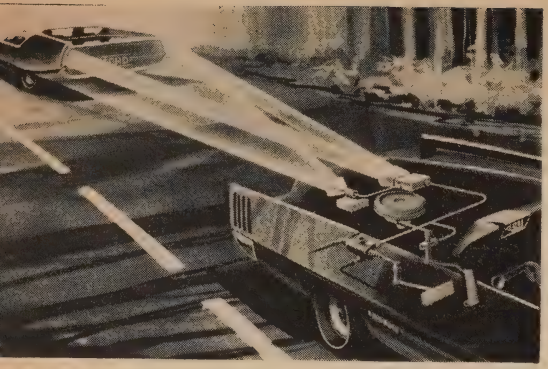


Fig. 3. Ford system uses an invisible beam reflected by the car in front.

When the test signal is detected, it passes through the system and is detected as if it were a target. If the test signal is not detected, a fail light comes on and the system is deactivated.

The Ford system, designated Automatic Headway Control (AHC), is essentially a computerized brake and throttle control unit similar to the Bendix system. On the open road, AHC operates as a conventional speed-control device. When an AHC-equipped car approaches another vehicle from the rear, an optical beam is reflected from the taillights of the car in front to an electronic processor which "reads" the signal and changes accelerator and brake settings as needed to maintain a safe following distance. The driver needs only to steer the car. The basic operating elements and how the optical beam is used to detect another car's presence are shown in Fig. 3.

Back-Field Detection. Headway control alone does not cover some of the other critical driving hazards. Studies have shown that blind spots in rear vision are contributing factors in many accidents involving cars going in the same direction. Bendix, Ford, Sylvania, and others are developing systems to warn the driver of the presence of traffic or objects in these blind areas.

The Bendix system is composed of two lane-changing sensors and a back up sensor. The sensors are CW homodyne radars. The approximate coverage of each sensor is shown in Fig. 4.

The antennas for the lane-changing sensors can be mounted next to the car's taillights. The antenna patterns are designed to intersect adjacent lanes and illuminate the blind areas. When a vehicle enters the illuminated zone, the driver is warned of the presence of an approaching vehicle. (The radars are designed to ignore roadside objects.) The lane-changing radars have a maximum range of 50-70 ft with a minimum range response down to the center door post to cover the entire blind zone.

The antenna for the back-up sensor can be integrated into the rear bumper. The sensor is inoperative until the car is placed in reverse. Visual and audible warning is activated when the presence of any object is detected in the sensor's range of view. The antenna pattern is centered on the road surface 10 ft behind the car with range being 0-30 ft.

The Ford system uses an infrared laser diode, a semiconductor IR detector, and an optical system mounted behind the rear axle to detect small objects up to 10 ft directly behind the car. It does not provide lane-changing protection. However, it seems likely that this feature will be incorporated into a production model.

The system is activated when the automatic transmission lever is placed in park, reverse, or neutral. When an object is detected, a warning buzzer sounds for 3 seconds and a warning lamp lights up. The warning lamp remains lighted until the object leaves the field of view or the system is deactivated by turning off the ignition or shifting to drive.

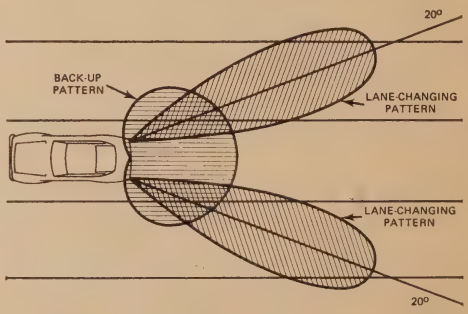


Fig. 4. The Bendix rear-end warning system provides detection for backing up or for changing traffic lanes.

A simplified diagram of the Ford Back Up Warning System is shown in Fig. 5. When the ignition is on and transmission is in park, reverse, or neutral, the system is activated. A self-starting 500-kHz free-running multivibrator provides the timing for the system. When the multivibrator's out-

RCA SYSTEM USES TWO-WAY RADAR

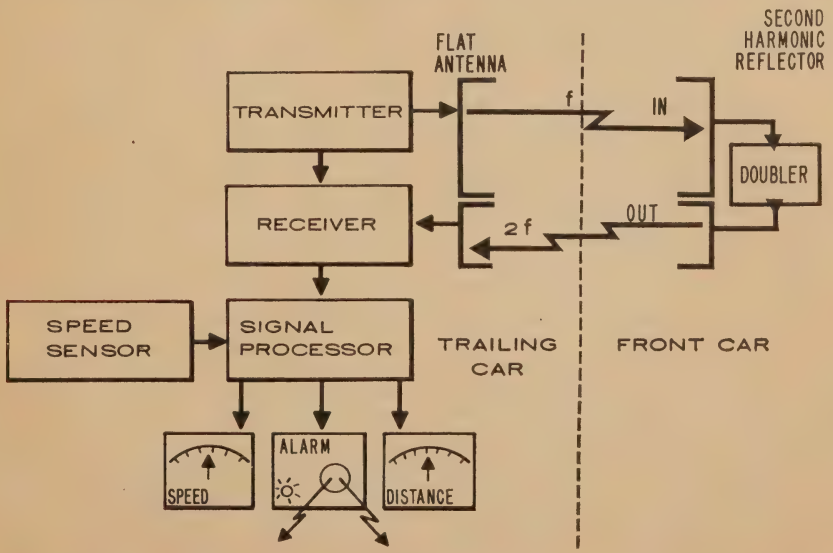
A COLLISION prevention system designed by RCA uses a new look in vehicle radar. A compact radar transmitter and receiver, measuring only 17 × 8 × 2½ in., is mounted on the front bumper (or behind the grille). It transmits a 100-mW, 9-GHz signal which is vertically polarized with an effective beamwidth slightly less than 5 degrees. The receiving antenna is horizontally polarized.

The "target" vehicle uses a rear-mounted passive antenna that is 17 × 8 × ½ in., which accepts the signal from the following vehicle and, using special solid-state diode microstrip filters, re-radiates the signal back to the following receiver at twice the frequency. The return signal is horizontally polarized.

The difference in frequency between the transmitted and received signals is used to determine the distance between the two vehicles. If the distance exceeds a predetermined amount, a warning light and buzzer are turned on. The range is about 100 yards and the narrow beamwidth of the transmitted signal enables operation only in one traffic lane. Also, since the radar receiver is horizontally polarized and only accepts signals at 18 GHz, oncoming vehicles fitted with the same system do not interfere. Natural objects do not provide the proper return.

Radar transmitter is mounted on front bumper or behind grille or license.

Transmitter, operating at 9 GHz, radiates a vertically polarized signal which is picked up by passive antenna on the back of the target car. Signal is then returned to following car at 18 GHz. This approach avoids background clutter.



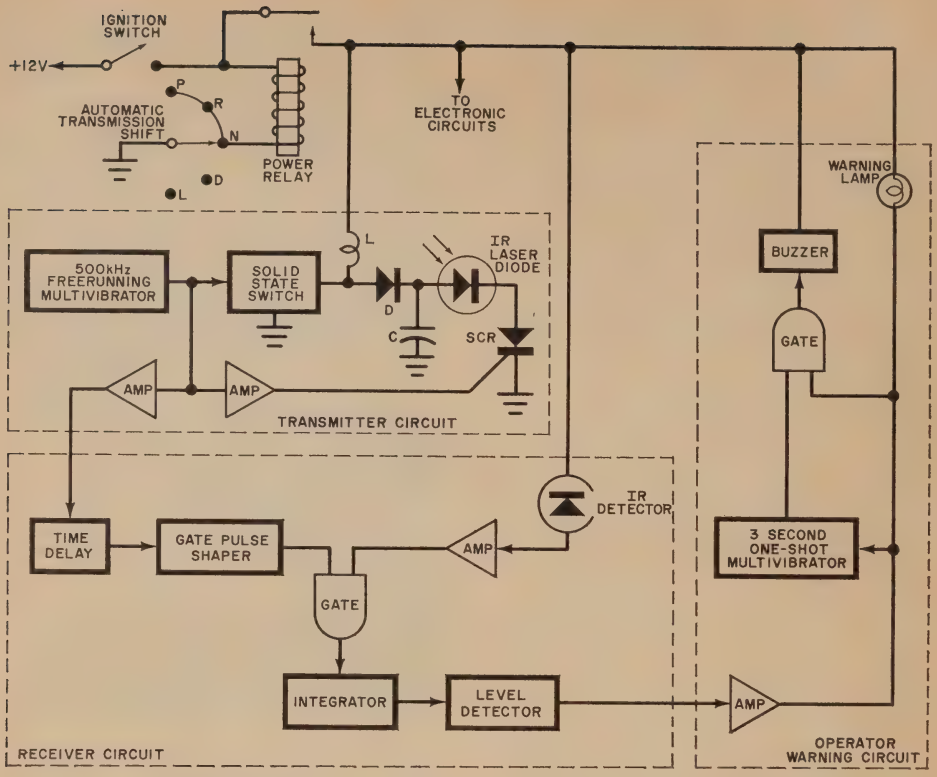


Fig. 5. Simplified diagram of Ford back-up warning system showing operation.

put is near ground potential, the solid-state switch closes and energy is stored in inductance L. The stored energy is transferred to high-voltage capacitor C as the output swings positive, turning off the solid-state switch.

At the beginning of the next cycle, the falling edge of the multivibrator signal triggers the SCR into conduction. The positive charge in C is discharged very rapidly through the laser diode and SCR, producing a 300-ns, 100-A peak current pulse to fire the laser diode. At the same time, the SCR trigger signal is transferred to a time-delay circuit in the receiver. This signal is then gated with return signals from the IR detector.

The output of the gate is applied to an integrator which averages the gated receiver signal over many cycles to reduce the effect of spurious signals. The output of the integrator is compared to a preset threshold level. When the threshold is exceeded, a signal is sent to a warning circuit. This signal triggers a one-shot multivibrator and lights up a warning lamp. In addition, it is gated with the output (3-second pulse) of the one-shot multivibrator and is used to energize a buzzer.

Sylvania's Wakefield Development Laboratory has developed a prototype ultrasonic safety detector that automatically warns when another vehicle approaches from the rear. The system can be installed in the rearview mirror or the rear light assembly. It responds to noise generated by the engine and tires of a vehicle travelling at least 35 mph within 25 ft of the detector. When an approaching vehicle is detected, the system turns on a warning lamp.

Sylvania claims that their method of detection is better than forms using radiation detection methods because it can discriminate between moving and stationary objects along the roadway.

It appears that any of these collision prevention systems will be a boon to any driver who encounters changing traffic and weather conditions. Optimistically, they may one day eliminate the awful toll of lives lost on our nation's highways which now stands at over 50,000 victims annually. ◈

Nuclear Radiation & Detection

Part 1: Types of Radioactivity

WHERE ALPHA, BETA, AND GAMMA RADIATIONS COME FROM AND THEIR CHARACTERISTICS

BY J. G. ELLO, Radiation Measurements and Instrumentation
Electronics Division, Argonne National Laboratory

ABOUT 30 years ago in Chicago, scientists built and successfully operated the world's first nuclear reactor. Basically speaking, the scientists had an atomic bomb detonation under control. Since then, the atomic age has progressed into many fields throughout the world.

Radioactivity, for example, is used in prospecting for ore, coal, and oil deposits. Space satellites and deep sea research use radioactivity to provide electrical power; hospitals use it for tracers, cancer research, and treatment; and its tracers are used in agriculture for fertilizer improvements. Radioactivity is also used in crime detection to identify pollution and determine the age and history of various materials.

Currently, radiation is being used in industry to determine the density and thickness of various materials. Sterilization and pasteurization of food and insect control are other areas in which radiation is being used. Perhaps the greatest potential use of all is in the generation of electrical power.

Radioactivity is not new on earth. It has been around ever since the earth was formed, even though we are only now beginning to put it to use. In 1895 when radioactivity was discovered, W. C. Roentgen in Germany was experimenting with electrical discharges through evacuated glass tubes when he discovered the rays coming from the tubes were able to cloud photographic plates and ionize gases. In his notes, he referred to these rays as X rays.

Following the discovery of X rays, the French physicist, H. Becquerel, found that a piece of uranium would also darken photo-

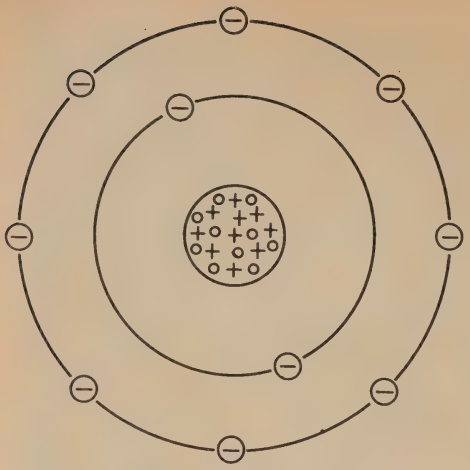


Fig. 1. Makeup of a stable neon atom.

graphic plates. In 1898, Pierre and Marie Curie discovered that other elements which they named radium and polonium also emitted rays that could ionize gases and darken photographic plates. They called this phenomenon "radioactivity."

In 1899, while studying in England, New Zealand physicist E. Rutherford found that, when radioactivity passed through thin sheets of aluminum, its ionizing power was reduced. From this, he concluded that the radiation emitted from uranium was made up of two types which he called alpha and beta radiation. In 1900, a third type of radiation emitted from uranium was discovered by P. Villard. Finding it to be similar to X rays, he named it gamma rays.

Elements. For 2000 years, dating from the fifth century B.C., it was believed that all matter was made up of four elements—fire, air, water, and earth. For many centuries, ancient alchemists attempted, without results, to change base metals into gold. With present technology, however, it is possible to transmute or change one element into another.

It was not until about 1789 that Lavoisier established that an element was a substance containing only one type of matter which could not be split into anything simpler. He listed about 30 such elementary substances of which about 20 are to this day regarded as elements.

By 1819, the number of elements was increased to 50. Presently, there are 92 known natural elements. Among these are gold, silver, nickel, lead, and uranium. With modern technology, elements can be produced by transmutation and disintegration. These include americium, curium, berkelium, plutonium, and neptunium (the latter two, a result of the atomic bomb).

The current count of elements, including those which are man-made, is 103, by now possibly 105.

Radioactive Atoms. Since radioactivity is concerned with the disintegration or decay of an atom, it is worthwhile to take a close look at the atom. The atom is held together by a force of attraction. It consists of a nucleus and orbiting electrons. In a very basic sense, the atom is similar in structure to the Solar System with the sun as the nucleus and the planets as the orbiting electrons. The planets in our Solar System are held together by gravitational force. The atom, however, is held together by an electrical force.

A stable neon atom is shown schematically in Fig. 1. In its nucleus are 10 protons and 10 neutrons. Orbiting around the nucleus are 10 electrons, two of which are in the inner ring and eight in the outer ring. The protons carry a positive (+) charge, the electrons a negative (−) charge, and the neutrons are neutral, having no (0) electrical charge. Similarly, a uranium atom consists of a nucleus with protons and neutrons and a comparable amount of electrons (92) in seven rings. Uranium, however, is not a stable atom. It will decay until it eventually becomes lead.

When uranium, radium, or plutonium decay, they give off particles and rays—radiation. It takes one pound of uranium about 4.5 billion years to decay to one-half pound and another 4.5 billion years to decay to a quarter pound, and so on. The rate of decay for radioactive elements is based on the elements' half-lives, which vary from element to element. For example, the half-life of radium is about 1600 years, plutonium about 24,000 years. Other radioactive elements may decay in less than a millionth of a second.

Alpha, Beta & Gamma Radiation. From the very beginning, man has been bombarded by cosmic radiation from the sun and the distant stars. Owing to the atmospheric shield with which nature has provided us, the cosmic rays are reduced to intensities we consider harmless.

The natural radiation with which we must contend as part of our environment

is defined as alpha, beta, and gamma types. How the three differ in their penetrating power and their course in a magnetic field is shown in Fig. 2. It has been stated that radium and uranium each emit all three types of radiation as they decay. However, it should be understood that not all radioactive elements give off all three types of radiation.

The alpha type, first described as a "ray" but later found to be a particle, is a helium atom with a positive charge as a result of having lost two of its electrons. The alpha particle is ejected from a radioactive atom at a velocity about 1/20 that of light. The alpha particle has a high kinetic energy potential as a result of its high speed and large mass. It loses a little of its energy each time it collides with another atom. The energy is dissipated each time it knocks an electron out of an atom with which it collides; during the process ions are formed. Although the alpha particle can travel through 1-3 in. of air, it cannot penetrate a few sheets of newspaper. Too, being a positively charged particle, it can be deflected in a magnetic field.

The beta particle, like the alpha particle, is also emitted from the nucleus. But the beta particle can travel several hundred times farther than the alpha particle and at a velocity approaching that of light. It can be absorbed by a ¼ in. thick sheet of Lucite. The beta particle has the same mass and charge as an electron, and compared to an alpha particle, it has 7500 times less mass. Therefore, a beta particle with the same energy as that of an alpha particle will travel much farther and faster before it is completely absorbed by collisions with other atoms. Similar to the alpha particle, the beta particle leaves ions in its wake. Through the use of electronic equipment, these ions (in both cases) provide us with much useful information.

The third type of radioactivity is known as the gamma ray. Unlike alpha and beta particles, the gamma is a ray—not a particle. It is an electromagnetic wave, similar in behavior to radio waves and microwaves, ultraviolet waves, and X rays. To be more precise, gamma rays are X rays of very high frequency and very high penetrating power. While alpha particles are absorbed by a few sheets of newspaper and beta particles by a ¼ in. thick sheet of Lucite, it may take several inches of lead to absorb radium's gamma rays and several feet

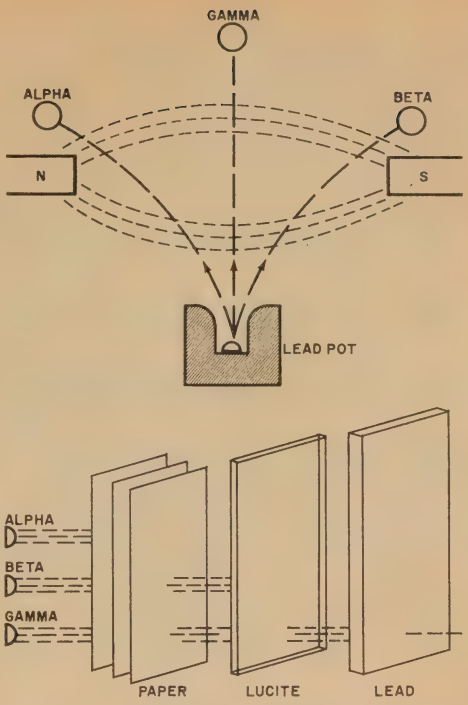


Fig. 2. Courses in a magnetic field (top) and penetrating powers (bottom) of alpha, beta, and gamma radiation.

of concrete to absorb gamma rays produced by nuclear power reactors. Since gamma rays are not particles, they are unaffected by a magnetic field.

Gamma rays are emitted from the nucleus of an atom when an excess of energy remains after the ejection of an alpha or beta particle. Unlike alpha and beta particles which produce ions in their wake, gamma and X rays produce ionization through a secondary effect. When a gamma ray enters an atom, it will more likely dislodge an electron which will, in turn, ionize other atoms by dislodging other electrons in its path. As we shall see in Part 2 in this series, the secondary ions are collected in a detector and the count indicated on a radiological survey meter.

More To Come. We have come to the end of Part 1 in this three-part series. In this instalment we have presented and discussed the various types of radioactivity. Parts 2 and 3, which will deal with Radiation Detectors and Radiological Survey Meters, will be presented in the November and December issues. ◈

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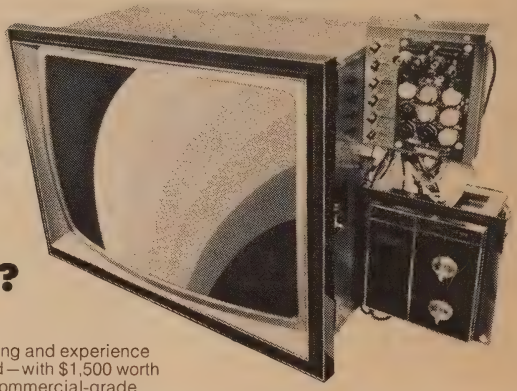

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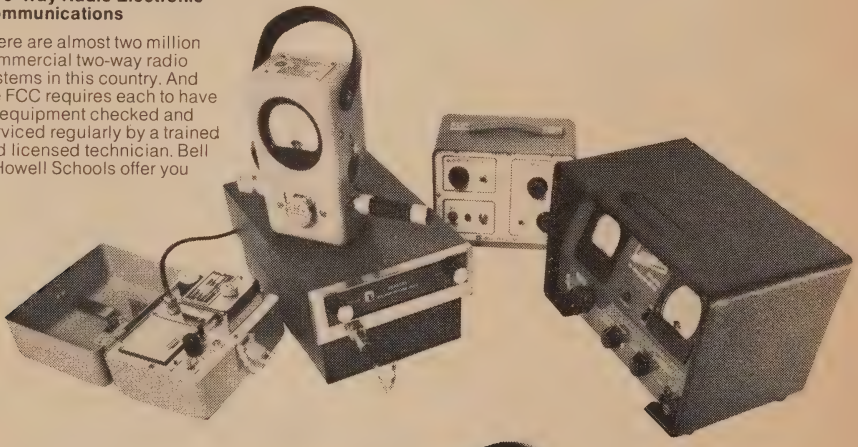

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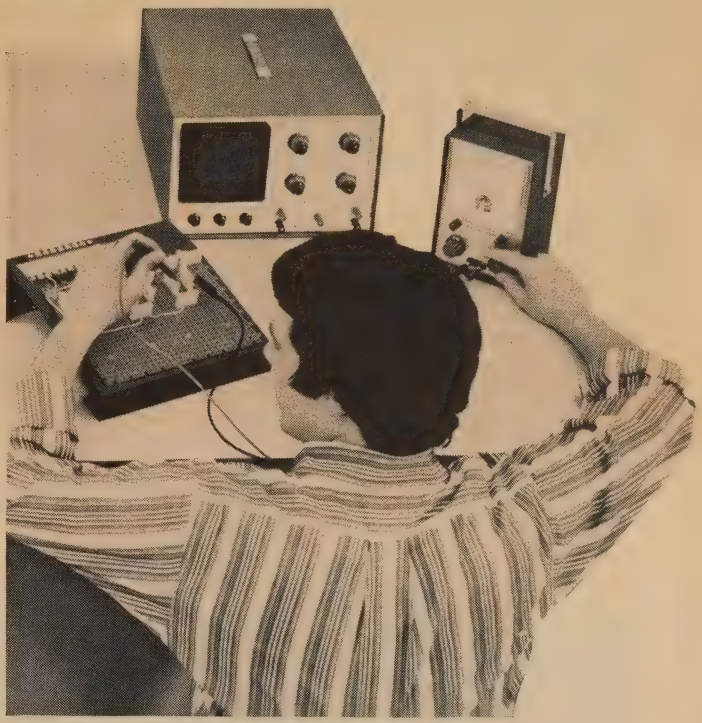

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UNDERWATER TREASURE DETECTORS

THE KIND OF EQUIPMENT NEEDED BY THE MARINE PROSPECTOR

BY L. GEORGE LAWRENCE

UNDERWATER treasure hunting can be an exciting and rewarding pastime—provided you have advance knowledge of what to expect for your efforts. Underwater work requires auxiliary equipment not needed for dry-land hunts. It involves many safety precautions, and you must be in excellent health and physical condition. It is also a vastly more expensive pursuit than is dry-land treasure hunting.

Typical marine hunts deal with very large objects (such as sunken ships, airplanes, and cannon) and small items of great value. In the latter category, gold coins hold the most interest.

Because the sea has no reference marks like those found on dry land, special position-fixing gear is required to mark a search site. Buoys can be used for this purpose, but they can compromise a "find" should one be made. Electronic or optical fixing by triangulation, on the other hand, assures the secrecy marine prospectors require.

Search Equipment. There are several methods available for locating large objects

Fig. 1. Varian's proton free-precession magnetometer can be used on land; or, with the sensor head shown at right waterproofed, in an underwater environment.

like sunken ships. The best are magnetometers.

Institut Dr. Förster (Reutlingen, West Germany) makes the Submarine Search Magnetometer which has been used with outstanding results in international waters. Its probe is lowered to the sea floor from a boat while a meter on an on-board instrument case indicates the presence, if any, of iron or steel near the probe. This magnetometer is of the flux-gate type which can be used underwater and adapted for dry-land use.

An outstanding American-made magnetometer is Varian's proton free-precession instrument shown in Fig. 1. It too is suitable for both dry-land and marine use. Marine use involves little else than housing the proton head (to the right in the photo) in a waterproof container and running a low-loss shielded cable to the read-out package aboard ship. The Varian magnetometer is a total-field device which expresses changing gamma values by means of a vibrating-reed meter.

Less costly and simpler underwater detectors are the zero-drift beat-frequency devices patterned after dry-land equipment. The Garrett Electronics Shark features multiple-coil capabilities; a single 5-in. coil and a single 12-in. coil are rigidly encased in unbreakable plastic and switched into operation by means of a manual control located on the faceplate of the detector. The 12-in. coil is used to search for larger, more deeply buried objects, while the 5-in. coil is used for searching out small coins and objects down to the size of a BB pellet. Used by scuba divers, the Shark provides no-glare observations by means of an illuminated meter. Its service depth is 300 ft; its price is $595.

Other less expensive and highly versatile designs are also available. White's Electronics, for example, makes the Goldmaster Amphibian BF-4 which employs a 4-in. search coil and operates on the beat-frequency principle. It features an underwater headphone which can be fitted to a wet suit.

Like similar designs, the Goldmaster Amphibian can spot *any* metal, making it unnecessary to break open and destroy coral reefs just to determine whether or not metal items are within. The instrument's case is designed to withstand depth pressures up to 400 ft. The list price of the BF-4 is $199.50.

Towing Equipment. A great problem is encountered when an attempt is made to rapidly scan marine areas containing metal with economical—yet reliable—equipment. The key to success, of course, is to have the detector in close proximity to the objects sought. In typical operations, a beat-frequency type of locator or a magnetometer sensor can be lowered at a distance behind the search boat with the sensor being allowed to operate near the sea or river bottom. The boat's speed in this approach is fairly critical since the sensor's depth is a function of its weight, the boat's speed, and the hydrodynamic pattern, including water resistance, encountered.

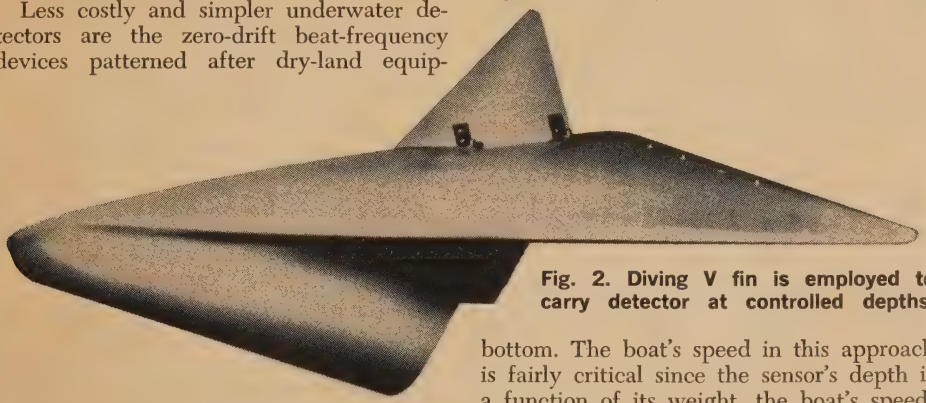


Fig. 2. Diving V fin is employed to carry detector at controlled depths.

One solution to maintaining proper depth is the diving V fin (see Fig. 2) developed by Braincon Corp. Originally designed for deep-sea thermometry studies in the Gulf Stream, the V fin design was modified to carry metal locators at any desired depth. Of course, nature poses serious restrictions. If a find is in very deep waters, economical recovery is well nigh impossible.

Power winches are required to launch and retrieve the V fin. A steel cable pulls the fin when it is in the water. An electrical cable interconnects the submerged sensor with the on-board electronics package. ◈

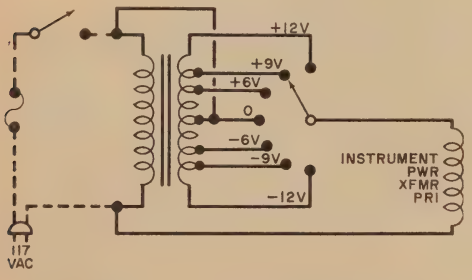
POWER-LINE BOOSTER/REDUCER

OFFSET VOLTAGE FLUCTUATIONS SIMPLY AND INEXPENSIVELY

BY FRANK H. TOOKER

POWER-LINE fluctuations are common occurrences these days. In some localities, periodic voltage increases can be observed. In other localities, especially in large urban areas where peak demand can exceed the power company's ability to supply, voltage reductions are a way of life. Whether they are increases or decreases, changes in the line voltage that is supplied to some test instruments can have adverse effects on the instruments' operation.

It is necessary, therefore, to supply any voltage-sensitive instruments on your workbench with a facility for offsetting power line fluctuations. To accomplish this, you can install a booster/reducer right in the equipment by connecting a transformer in the primary circuit of each instrument.



Instruments that are voltage-sensitive must be protected from power-line fluctuations. This circuit does it easily with only a transformer and rotary switch. Addition or subtraction of 12 volts is obtained in 3-volt increments taken from taps on transformer.

Ordinarily, a power-line booster/reducer requires several switches to provide the needed functions. This makes the setup shown in the schematic diagram especially interesting inasmuch as the boosting, reducing, and in/out functions are all accomplished by means of a single 7-position rotary switch. A multi-tap transformer, with three outputs on each side of the center-tap, makes the simplification possible.

With the switch set at its center position, the output voltage from the transformer into the instrument's power transformer primary is unchanged from that supplied by the ac line. However, when the switch is set to any other position, the system adds or subtracts the amount of voltage selected from the line-voltage level. By this means, a maximum addition and subtraction of 12 volts can be obtained in 3-volt increments, starting at 6 volts. Electrically, whether addition or subtraction takes place is a matter of phasing.

The Burstein-Applebee Co. Stock No. 13A-902 transformer, which can be purchased for $3.99 plus postage, is rated at 1 ampere. It is very well made, with the primary and secondary wound on a nylon bobbin. When selecting a rotary switch, get one with contacts rated at 1 ampere at 117 volts. If possible, choose a ceramic type over the phenolic type.

Most test instruments have more than enough space inside their cabinets to accommodate the extra transformer. If this is the case in your instrument, locate the booster/reducer transformer as close to both the instrument's power transformer and fuse assembly as possible.

Unless the front panel of the instrument is extremely crowded—and few are—the add-on rotary switch can be mounted in any convenient location on the panel. However, when mounting the switch, make absolutely certain that it does not interfere with the operation of other switches and controls nearby. Also, when wiring the switch to the booster/reducer transformer and the primary of the instrument's power transformer, use No. 18 stranded wire. If practical, use the heavy wire leads on the add-on transformer to connect it to the switch. Do not ground any part of the add-on assembly. ◈

TRANSPARENT CERAMICS for ELECTRO-OPTICS

NEW CERAMIC MATERIAL CAN BE USED TO CONTROL LIGHT

BY NIGEL S. HEY
Sandia Laboratories

ELECTRO-OPTICAL devices have been in use for quite a number of years, from Edison's first incandescent light bulb to modern light-emitting diodes and research dye lasers. Simply by closing a switch, these devices operated exactly as they were designed to. However, in the attempt to modify the light after these devices are turned on, problems begin to appear.

To solve the problems of light processing, Sandia Laboratories in Albuquerque, New Mexico, has developed a new ceramic device which offers an alternative to traditional Kerr and Pockels cells and other mechanical contrivances. The new ceramic is similar to that used as the piezoelectric transducer in phonograph pickups. The big difference is that the new ceramic—hot-pressed and doped with lanthanum, a metallic rare-earth element—is transparent.

When sandwiched between crossed polarizers, the lanthanum-modified lead zirconate-lead titanate (PLZT) ceramic acts as a variable color filter or transmits light intensity in response to an applied voltage. Used in a "scattering" mode, it displays black and white images without the need for polarizers. Most important, PLZT has a built-in memory.

At least a minor revolution in electro-optic technology is promised by PLZT. The ceramic can be used to modulate lasers for communication purposes; extract colors from white light; store information in binary or decimal form; turn on and off light beams; and store and display images. Variations of PLZT are suited to special applications like high-contrast shutters or memories which retain stored information until erased.

How It Works. Let us take a microscopic look at PLZT. The material consists of randomly spaced PLZT "crystallites," in which each unit cell is arranged like a cube with lead and lanthanum ions at the corners, oxygen ions in the center of each face, and a titanium or zirconium ion in the center of the cube.

In this configuration, both the unit cell and the crystallite are electrically neutral. But in "slim loop" PLZT, the central titanium or zirconium ion is displaced toward one of the oxygen ions when an electric field is applied. The unit cell distorts into a tetragon and becomes an electric dipole. Clusters of unit cells align in the same direction to form a domain dipole.

Increasing the electric field increases both the magnitude and alignment of the domain dipoles. When the electric field is removed, the domain dipoles disappear and the ceramic returns to its electrically and optically isotropic state.

In ferroelectric or "wide loop" PLZT, the unit cell is spontaneously distorted, causing domain dipoles to exist with no applied electric field. When an electric field is applied, it causes domains favorably aligned with respect to the field to grow at the expense of others and produces increased domain alignment.

Controllable dipole alignment is the basis of PLZT's remarkable versatility. This alignment determines whether or not the material is birefringent (high or low double

Positive image stored in a ceramic electro-optic device. Plate is 1 in. in diameter and is 0.0123 in. thick.

refraction) and the magnitude of the birefringence. In another mode of operation, dipole alignment controls the ceramic's light-scattering properties.

Birefringence has the effect of changing the polarization of plane-polarized light. By controlling birefringence, one can also control the amount or color of light penetrating a polarized filter. Hence, PLZT can be said to be a solid-state analog of the Kerr cell which exhibits a quadratic electro-optical effect. Alternatively, using a different chemical mixture, PLZT exhibits a linear electro-optical effect similar to a Pockels cell.

Unlike the Kerr cell, PLZT is solid-state and compact. It is less expensive to make and has a much larger electro-optical effect than does potassium dihydrogen phosphate (KDP) and lithium niobate crystals commonly used in Pockels cells. For the same applied voltage, 12 times the effect of KDP is produced by one composition of PLZT.

Electro-Optical Memory. The one feature of PLZT that is unique is its electro-optical memory. When the polarizing electric field is removed from "wide loop" PLZT, the domain dipoles do not return to a random orientation. The ceramic remains birefringent and stays this way until changed by electrically reorienting the dipoles. The dipoles can be returned to a random orientation by raising the temperature of the PLZT to its Curie point.

In PLZT materials, the applied field-versus-birefringence plot follows a hysteresis curve. Typically, memory-type PLZT exhibits a certain maximum retardation (saturation) while the field is applied. When the field is removed, the material relaxes into a remanent (residual) state with a lesser birefringence. Subsequent electric field pulses can be used to switch the ceramic into other remanent states.

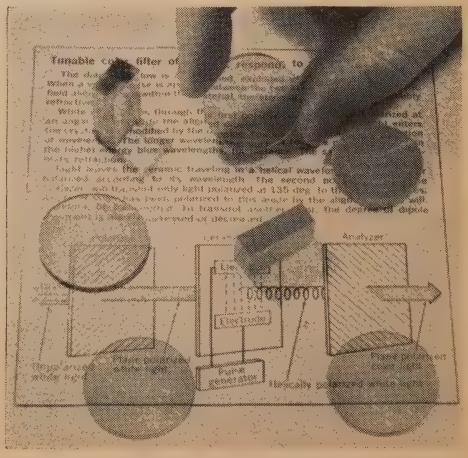
Device Applications. Many device applications present themselves when one considers the effect from a relatively simple device consisting of an electroded ceramic slice sandwiched between crossed polarizers. These include:

Memory material—light gates and shutters; optical memories which can be read without photocell arrays; controlled-persistence displays and electrically controlled spectral filters. For color effects, back lighting with plane-polarized light is used. Each frequency component of white light is affected by birefringence. By applying a specific voltage to the material, one color can be made to dominate as light penetrates the analyzer. Monochromatic light is used to achieve "amplitude modulation."

Pockels-effect material—linear light modulation and momentary light shutters. This material could be useful in modulating laser beams at frequencies up to approximately 10 MHz.

Kerr-effect material—quadratic light modulators and light shutters. This is an extremely promising material since it is para-

These variously shaped electro-optic ceramic pieces, made by new process, are very transparent and homogeneous.



electric at room temperature and, thus, optically isotropic. Virtually no light passes through the crossed polarizers of the device. When a field is applied, however, the crystallites distort and the ceramic becomes birefringent. When the field is removed, the material immediately relaxes to a para-electric state.

Longitudinal-Mode Ceramic. So far, devices in which an electric field is applied perpendicular to the direction of light propagation (transverse mode) have been discussed. But one major development has been pioneered at Sandia in which the field and light are applied in the *same* direction (longitudinal mode). The new device is called Cerampic.

In Cerampic, no birefringence is involved. The device works entirely by scattering light. Dark areas of the image scatter more light away from the viewing plane than do light areas. Non-image forming scattered light is then removed from the projected light beam with a contrast-enhancing pinhole aperture.

To make Cerampic, one side of a PLZT ceramic slice is coated with photoconductive polyvinyl carbazole (PVK). The device is then coated on both sides with transparent electrodes.

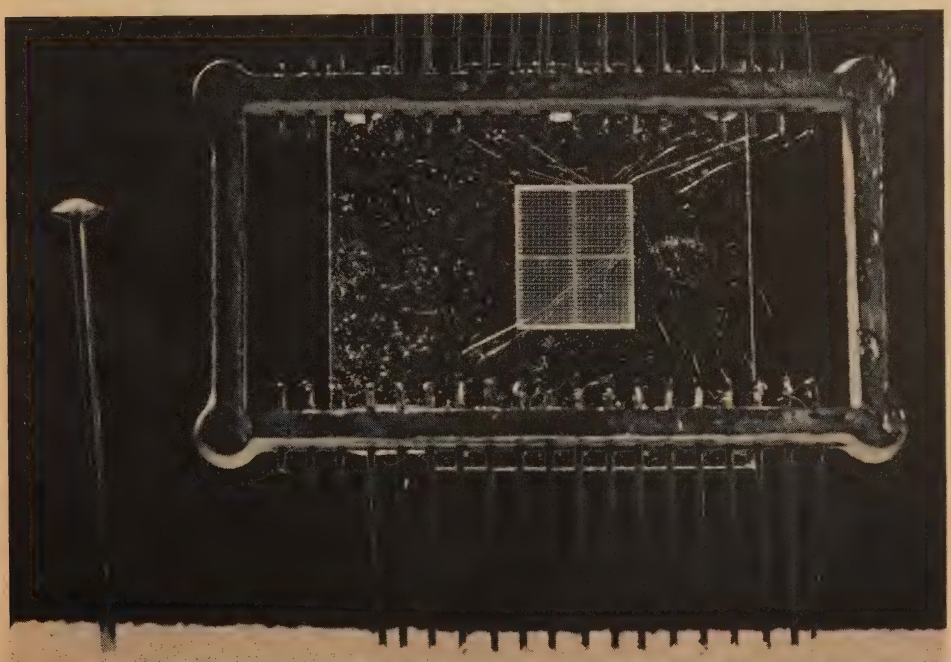
High-resolution images (up to 1000 line pairs/inch) are stored in this device by illuminating it with light through a photoraphic negative or with a scanning light beam while applying voltage to the electrodes. Light passing through the negative penetrates the transparent electrode and enters the PVK, decreasing electrical resistivity and allowing current to pass through the ceramic to the second transparent electrode. In this manner, the relative opacity (or scattering capability) of innumerable points on the ceramic plate is altered so that the device transmits various shades of gray in the form of an image. The image has memory, is erasable, and can be viewed directly or projected like a 35-mm slide.

A variety of potential uses is possible with Cerampic. Most promising is the generation of images from signals received by telephone or radio. These images could be generated in a few seconds or, conceivably, at rates of up to 15,000 lines/second.

Cerampic is being considered for use in optical information storage and processing systems. The new scattering effect may also prove useful in devices such as shutters, optical memories, and page composers for holographic memories.

Many companies are now working on devices that use PLZT as the basic working medium. Since the material was developed by Sandia Laboratories under a prime Atomic Energy Commission contract, the basic work is covered by patents held by the U.S. Government. This means that private companies may be licensed to develop and use the material on a no-royalty, revocable, nonexclusive basis. ◈

Prototype of ceramic memory element can store 5120 bits/sq in. Straight pin at left.



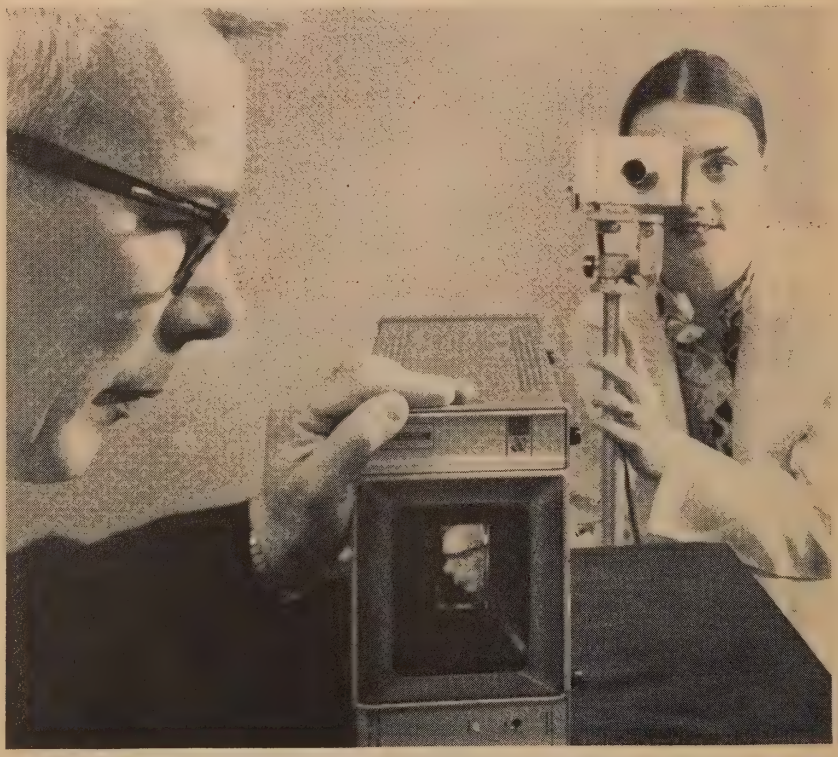
In This Corner: RCA

A SMALL research model of a solid-state black-and-white TV camera has been developed by RCA Laboratories and delivered to the Air Force Avionics Laboratory. The camera's integrated circuit image sensor consists of 32 rows of photosensitive elements with 44 elements in each row. Rows are spaced 3 mils apart, about the thickness of a human hair. When an image strikes the ½-in. square, an electrical charge proportional to the light intensity is produced in each element. The rows are then read out very rapidly in sequence to produce the TV-type picture.

The development could lead to a new generation of very small cameras with potential applications in military and space missions, news coverage, and perhaps for consumer use with home video recording and playback systems. The image sensor now has 1408 discrete elements; work is going on to increase this number substantially in order to get the resolution required for detailed TV pictures.

With the electronics all contained on IC's instead of separate PC boards, it should be possible to make the lens the biggest thing in the camera. Future cameras the size of a wristwatch are anticipated. Current model is 2 by 2¼ by 3¾ inches and weighs less than one pound.

Small TV camera at right is focused on subject whose image is seen on monitor. Work is in progress on camera to make it even smaller and improve resolution.



Developmental Image Sensors

SOLID-STATE TV CAMERAS

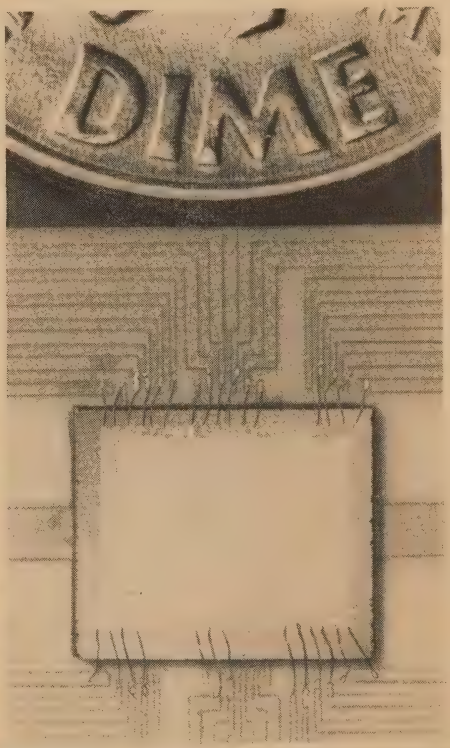
BELL LABS: In This Corner

ENGINEERS at Bell Laboratories have built an exploratory model of a new solid-state video camera that, like the RCA unit on the opposite page, consists essentially, of a flat chip of silicon covered with an insulating oxide over which is an array of metal electrodes. The image sensing system is a two-dimensional array of 128 by 106 light-sensitive cells. The active area of the device is 3 by 5 millimeters and the metal electrodes are nine micrometers wide, spaced two micrometers apart.

Like the RCA camera, Bell Labs' entry demonstrates an application of charge coupling, the semiconductor principle first announced by Bell Labs a couple of years ago. The Charge Coupled Device (CCD) operates by manipulating small packets of electrical charge within the solid slice of silicon. Light incident on the silicon is absorbed, creating an electrical charge which is stored locally at the surface of the silicon under the metal electrodes. The amount of stored charge is proportional to incident light flux. By varying the voltages on the surface electrodes, the charge is moved to an output electrode where it becomes an analog electrical signal representing light variations along the scanned line of the original picture.

Image on monitor at top is produced by solid-state video camera on workbench.

Chip of silicon covered with an array of metal electrodes is heart of camera.



Are Silicon Integrated Circuits

Build an Impedance Meter

MEASURE IMPEDANCE FROM ONE OHM TO ONE MEGOHM

BY CHARLES D. RAKES

THE ubiquitous volt-ohmmeter (VOM) can be used to make all kinds of resistance measurements, but it is an abject failure when it comes to measuring impedances. In fact, most hobbyists and technicians reach a dead end when they have to measure an impedance. There is no way to determine the impedance of a speaker, a transformer, an RL or RC network, etc.

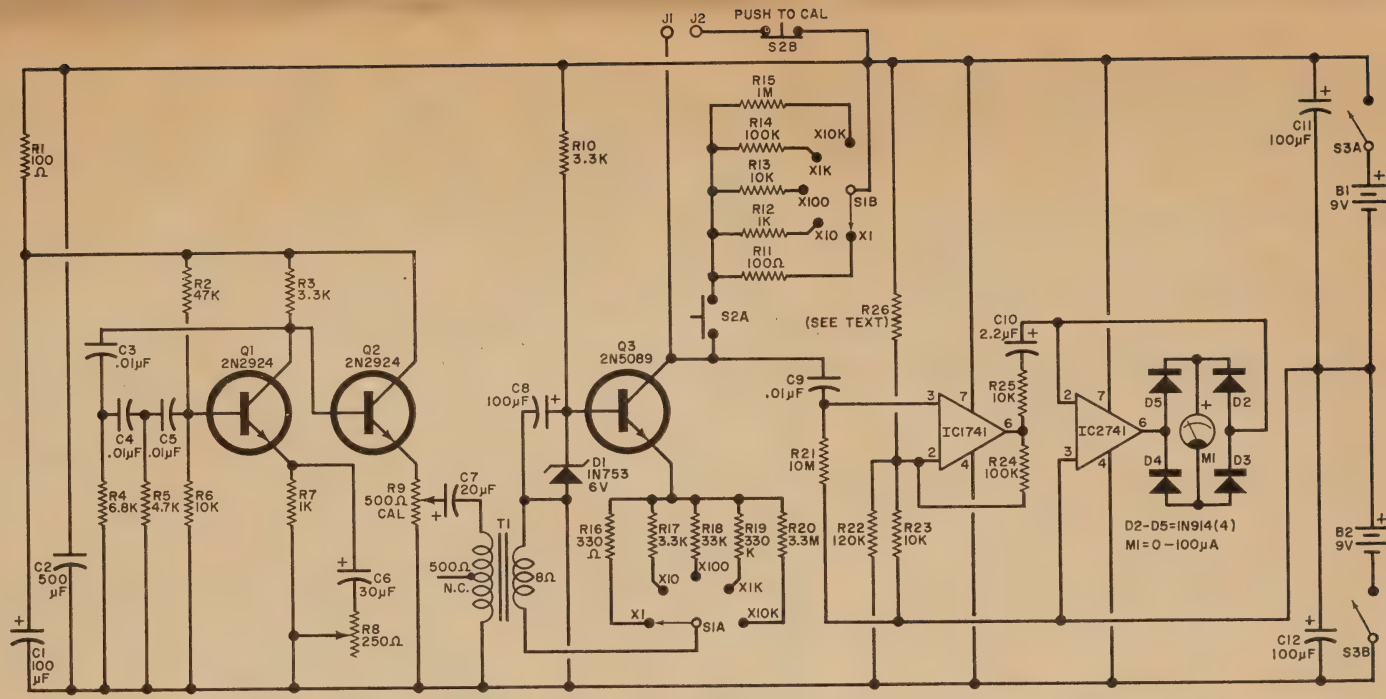
The Impedance Meter, whose schematic is shown in Fig. 1, includes five impedance ranges from zero to 100, 1000, 10,000, 100,000, and 1,000,000 ohms. The measurements are made at 1 kHz and the readout is a relatively large 0-100 linear-scale meter. The device is battery operated and costs about $35.

The only restriction in using the meter is that the dc resistance path through the reactive component under test must be equal to or less than, the full-scale value of the range used to make the measurement. This restriction has never interfered with any impedance testing to date because, if a component is to be classified as reactive, it must have a higher impedance than the dc path. The only component that cannot be tested is a capacitor.

Circuit Operation. Transistor *Q1* and its associated components form a simple 1-kHz phase-shift oscillator that is buffered by *Q2*. The output of *Q2* is taken from the level control, *R9*, and applied to the primary of *T1*. Transistor *Q3* is connected as a constant current source, and its output (collector) is coupled to *IC1*, an op amp circuit having a high input impedance and a gain of about 10. The next stage is *IC2*, connected as an ac voltmeter.

The output voltage of the constant current source depends on the values of the collector and emitter resistors. The base is held at a fixed voltage by zener diode *D1*. When an unknown resistance or reactance is connected to *J1* and *J2*, the amount of voltage developed across it is read on the ac voltmeter.

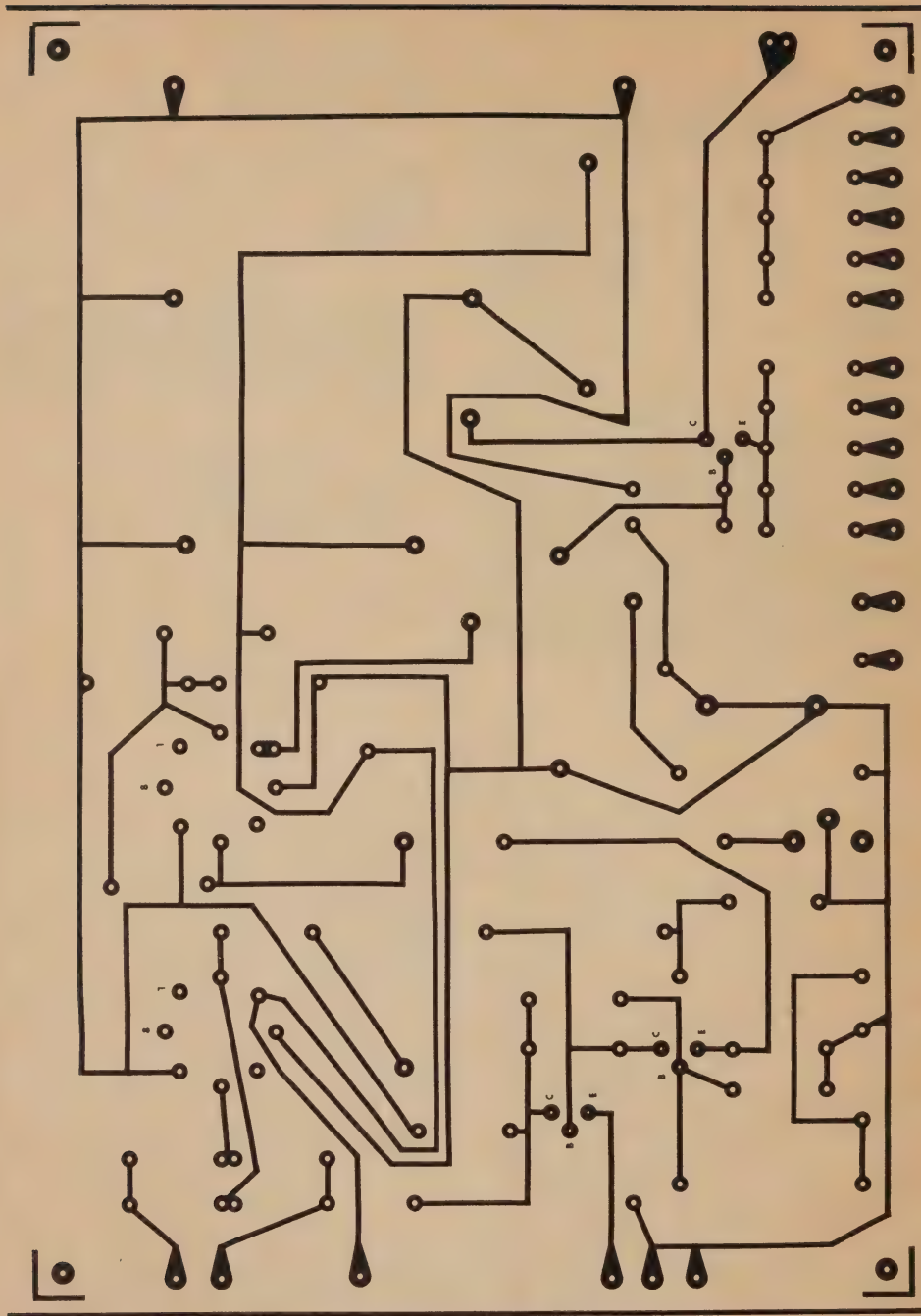
Construction. Any type of construction can be used; but if you want to use a printed circuit board (the best way), the foil pat-



PARTS LIST

B1, B2—9-volt battery (six AA cells)
C1, C8, C11, C12—100-μF, 25-volt electrolytic capacitor
C2—500-μF, 25-volt electrolytic capacitor
C3-C5—0.01-μF polystyrene capacitor
C6—30-μF, 25-volt electrolytic capacitor
C7—20-μF, 25-volt electrolytic capacitor
C9—0.01-μF paper capacitor
C10—2.2-μF, 50-volt polystyrene or Mylar capacitor
D1—6-volt zener diode (1N753)
D2-D5—Diode (1N914)
IC1, IC2—741 operational amplifier
J1, J2—Five-way binding post
M1—0-100-μA meter with linear scale
Q1, Q2—Transistor (2N2924)
Q3—Transistor (2N5089)
R1—100-ohm resistor
R2—47,000-ohm resistor
R3, R10, R17—3300-ohm resistor
R4—6800-ohm resistor
R5—4700-ohm resistor
R6, R23, R25—10,000-ohm resistor
R7—1000-ohm resistor
R8—250-ohm, PC potentiometer
R9—500-ohm standard potentiometer
R11—100-ohm, 1% resistor
R12—1000-ohm, 1% resistor
R13—10,000-ohm, 1% resistor
R14—100,000-ohm, 1% resistor
R15—1-megohm, 1% resistor
R16—330-ohm resistor
R18—33,000-ohm resistor
R19—330,000-ohm resistor
R20—3.3-megohm resistor
R21—10-megohm resistor
R22—120,000-ohm resisttor
R24—100,000-ohm resistor
R26—See text
S1—2-pole, 5-position non-shorting rotary switch
S2—Dpdt pushbutton switch
S3—Dpdt switch
T1—500:8 transistor output transformer
Misc.—Suitable chassis, battery holders, mounting hardware, etc.

Fig. 1. The circuit is easily assembled using PC board.



tern and component layout are shown in Fig. 2. The housing for the prototype is shown in the photo; but this is not essential. The meter, the range selector switch *S1*, the calibrate switch *S2*, control *R9*, the power switch *S3*, and two connectors should be mounted on the front panel. Mount the circuit board on spacers and use appropriate holders for the batteries. The value of *R26* is selected in the calibration procedure.

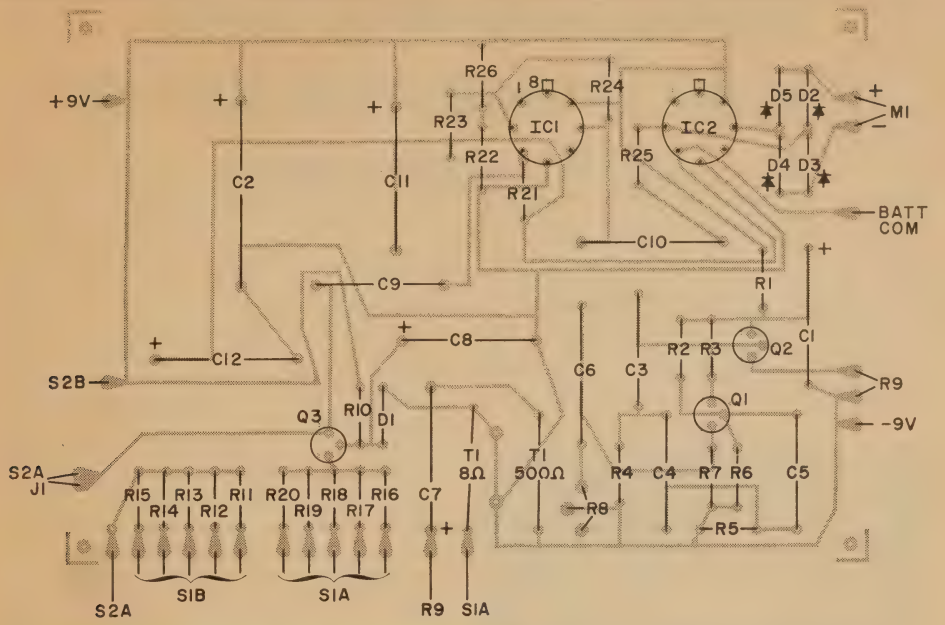


Fig. 2. The actual size foil pattern for a PC board is shown on facing page, while component layout is above. Perf board construction may also be employed.

Calibration. With all wiring checked, connect a 10-volt dc voltmeter between the common and pin 6 of *IC1*. With the power turned on, the meter can indicate either positive or negative at this point. Connect a resistance decade box between the *R26* terminals on the board and start with a resistance of 100,000 ohms. Increase this value until the dc voltmeter indicates zero. Select a standard resistor nearest to the decade-box value, and use this for *R26*. The voltage at pin 6 should be less than 1 volt.

Connect a 10,000-ohm resistor between *J1* and *J2*, and connect a scope in parallel with this resistor. Set *R9* about ¾ of the way toward maximum and put the range switch on RX100. Adjust *R8* (on the board) for the maximum peak-to-peak undistorted sine wave. Remove the scope and test resistor. Depress the calibration switch and adjust *R9* for a full-scale meter indication. Check each range of *S1* and note that a full-scale indication is obtained. If not, *R8* may have to be re-adjusted.

Applications. Any value of precision resistor (up to one megohm) can be used to check the various ranges. A wirewound resistor may provide false indications (not the same as the value marked on the resistor) because of the reactance of the windings.

To check speaker impedances, set *S1* to the lowest range. Use the same range for headphones and switch to higher ranges if necessary.

When testing transformers, load the secondary with the required resistance (to simulate the load) and read the reflected impedance on the meter.

If you suspect a shorted turn in a choke, transformer, speaker coil, or motor winding, the impedance meter can be used to verify your suspicion since even one shorted turn can cause the impedance of a normally high impedance to show some low value—near the dc resistance.

Either RL or RC networks can be checked easily but make sure there are no series capacitors in the circuit.

The first four ranges can be made as accurate as you wish by calibration (taking into account the tolerance of the meter and of the calibration resistors). The upper range (one megohm) can have an error as large as 5% due to the input impedance of *IC1*. ◈

Mobile Teleprinter System for Law Enforcement

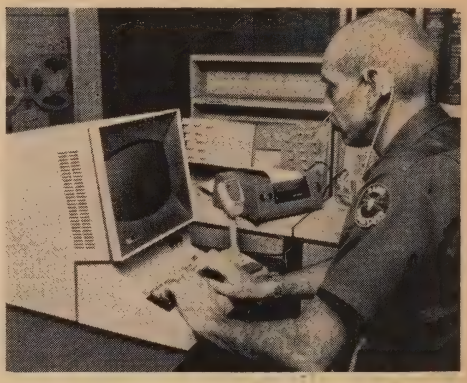
EARLY in December of last year, Sheriff Robert A. Bender of Allen County, Indiana, unveiled a unique mobile teleprinter system designed to provide a direct and automatic radio link between the patrolman in the vehicle and the regional, state, and federal crime information computer files. This first such system to be used in the U.S. employs Motorola teleprinters in ten patrol cars.

Officer in printer-equipped vehicle receives hard-copy response to query.

With the teleprinter system, officers in the printer-equipped vehicles would follow normal procedure in radioing the dispatcher for information on vehicle license numbers, wanted persons, etc. However, with the teleprinter on hand, the officers then receive a printed hard-copy response over a 2-way radio channel. Information requested is passed on directly and automatically from the Indiana regional crime information system computer in Fort Wayne to the patrol car.

Since teleprinter communications are transmitted in tone form, which can be decoded only by the printer system, all messages are completely secure. Consequently, if the dispatcher is alerted to a crime in progress, he can transmit this information to any and all vehicles equipped with the teleprinter without fear of unauthorized monitoring. Should an all-points bulletin or wanted persons' description be broadcast while an officer is away from his vehicle, the hard-copy message would await him on his return.

The printer system operates at a 100 word/minute rate to provide quickly and accurately any information required, even long descriptions and lists of detailed information. This means that the time between the request for and receipt of the information can be drastically reduced, making for more effective law enforcement. And to further reduce time, once the request is passed on to the information agencies, it is sent directly to the mobile teleprinter without having to go through the dispatcher.



Computer information retrieval and message switching are at headquarters.

When the system is finally completed, teleprinter-equipped patrol cars will have almost immediate access to the state criminal files in Indianapolis through the Indiana Data and Communications System as well as to the National Crime Information Center (the NCIC of TV law enforcement show fame) in Washington, D.C.

Serving as the Region II headquarters for the Indiana Criminal Justice Planning Agency, the Allen County communications network provides computer information retrieval and message switching functions for the law enforcement agencies in nine northeastern Indiana counties. ◈

Some of the reasons why other turntables don't perform quite like a Dual.

Because of the wide acceptance and acclaim Dual has earned over the years, especially among audio experts, many Dual features inevitably appear on competitive turntables.

To copy a Dual feature is one thing: to achieve Dual performance and reliability is quite another matter. The true measure of a turntable's quality is not its features alone, but how well the entire unit is designed and manufactured.

Following are just some of the ways in which Duals differ from other automatic turntables.

Gyroscopic gimbal suspension.

The gyroscope is the best known scientific means for supporting a precision instrument that must remain perfectly balanced in all planes of motion. That is why the tonearms of the 1218 and 1229 are suspended in true, twin-ring gimbals.

Every Dual gimbal is hand-assembled and individually checked with gauges especially developed by Dual for this purpose. This assures that the horizontal bearing friction of the 1229 for example, will be no greater than 0.015 gram, and vertical friction no greater than 0.007.

True single-play automatic tonearm.

A turntable of the 1229's caliber is used primarily in its single play mode, so the tonearm is designed to parallel a single record on the platter. For multiple-play, the entire tonearm base is moved up to parallel the tonearm to the center of the stack.

The 1218 tonearm provides the single-play adjustment within the cartridge housing, and the cartridge pivots around the stylus tip to maintain the correct overhang.

Stylus pressure around pivot.

Today's finest cartridges, designed to track at around one gram, have little margin for error. In the 1229, therefore, the tracking pressure scale is calibrated within 0.10 gram from 0 to 1.5 grams.

To maintain perfect balance on every Dual tonearm, stylus pressure is applied internally and around the pivot. This is accomplished by a very long spring coiled around the pivot. Only a small portion of the spring's length is needed to apply the required pressure, thus contributing greatly to the accuracy of the calibrations.

Avoiding sounds that weren't recorded.

The rotor of every Dual motor is dynamically balanced in all planes of motion. Each motor pulley and drive wheel is also individually examined with special instruments to assure perfect concentricity.

Any residual vibration within the motor is isolated from the chassis by a three-point damped suspension. Finally, every assembled Dual chassis is "tuned" to a resonance frequency below 10 Hz.

The best guarantee.

All these precision features and refinements don't mean that a Dual turntable must be handled with undue care. So we're not being rash when we include a full year guarantee covering both parts and labor for every Dual. That's up to four times the guarantee you'll find on other automatic units.

Now, if you'd like to know what several independent test labs say about Dual, we'll send you complete reprints of their reports.

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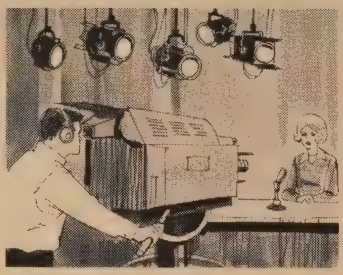

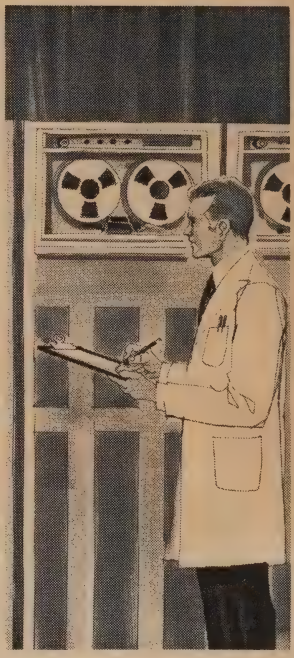

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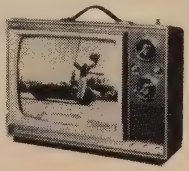

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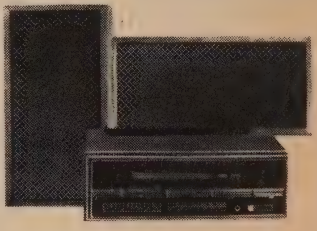

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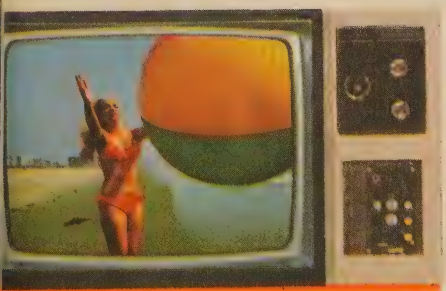

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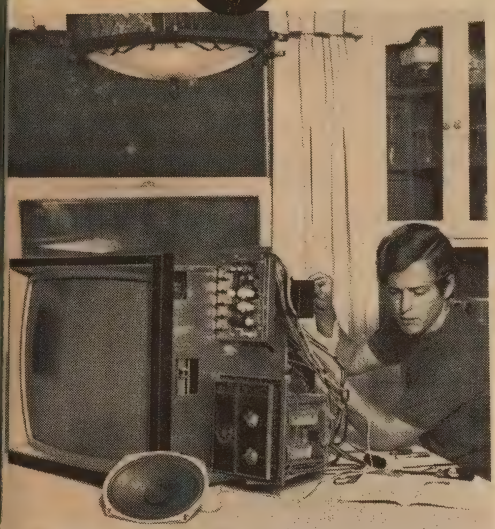

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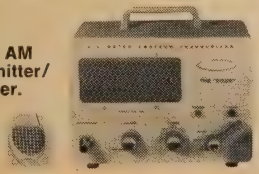

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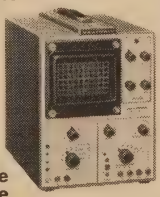

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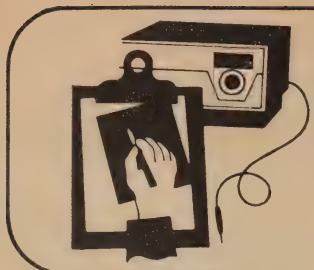


Product Test Reports

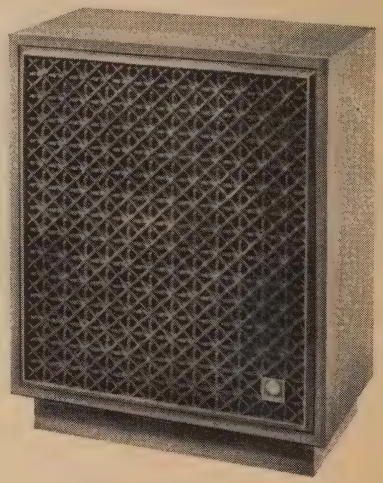
RECTILINEAR III LOWBOY SPEAKER SYSTEM
(A Hirsch-Houck Lab Report)

THE Rectilinear III Lowboy is a restyled version of the Rectilinear III speaker system which has been on the market for several years now. Since the original and Lowboy versions of this system use the same drivers and have the same interior volumes, they sound and perform exactly alike.

The Lowboy is a four-way system which contains a total of six cone-type drivers. The 12-in. woofer which operates in a ducted-port enclosure crosses over at a 6 dB/octave rate at 500 Hz to a 5-in. midrange driver located in a separate sealed compartment. This small 5-in. speaker which operates at frequencies up to 3000 Hz actually radiates most of the vitally important midrange sound.

At 3000 Hz, there is another 6 dB/octave crossover to a group of four tweeters arranged in a rectangular pattern on the upper half of the speaker board. Two of these drivers have 2½-in. cones; the other two have 2-in. cones. Although the tweeter group does not contain a crossover network, the larger drivers operate most effectively at frequencies up to 11,000 Hz, while the smaller drivers continue to operate to the highest audio frequencies.

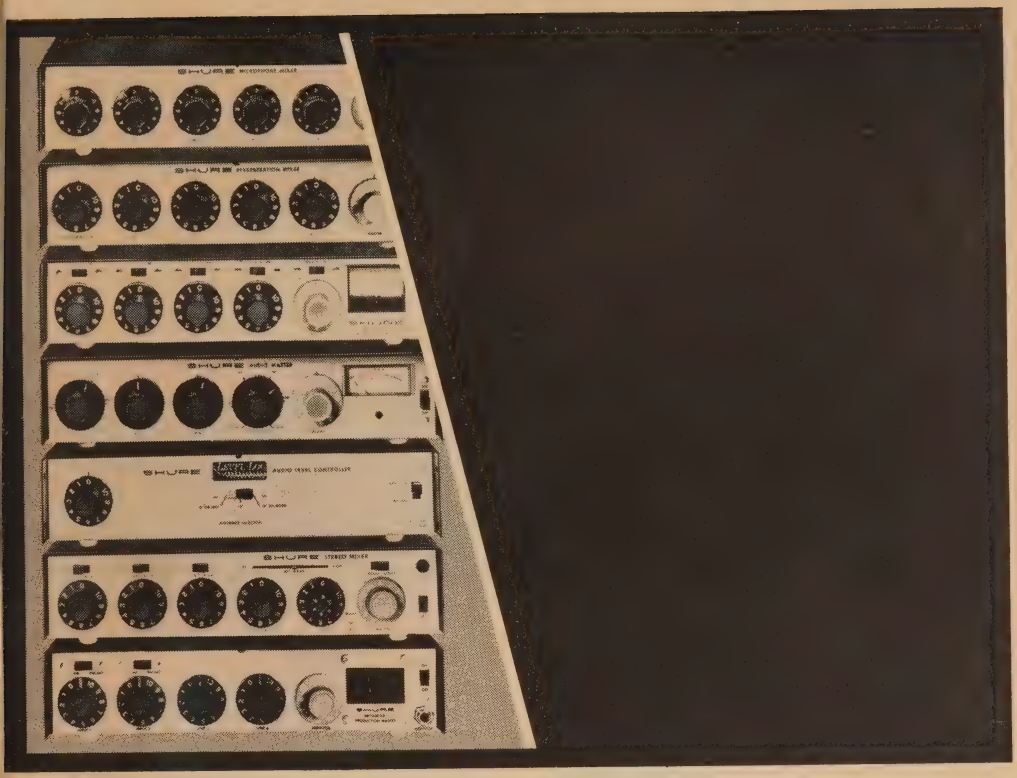
Frequency Response. Controls on the rear of the enclosure can be used to adjust the levels of the tweeter array and the midrange driver as desired. In our live-room frequency response measurements, we found that the flattest response was achieved with both controls set at maximum. The response was uniform within ±4 dB from 32 Hz to 15,000 Hz except for a slight increase in output at about 60-70 Hz (which may have been a property of the test room and measurement setup). The indicated "normal" control settings reduced the output by about 3 dB beyond 2000 Hz.



The speaker system is relatively inefficient. We had to drive it at a 10-watt level when measuring low-frequency distortion in order to overcome ambient room noise and system hum pickup. Even at this rather high level, though, the distortion was very low; typically 2.0 percent or less above 40 Hz, 5.0 percent at 36 Hz, and 10 percent at 31 Hz. The tone-burst response, an indication of transient response, was very good at almost all frequencies, although at about 10,000 Hz there were interference effects between the multiple drivers that made reliable tone-burst photos difficult to obtain.

The electrical impedance of the system was very uniform over the full audio range. It measured between 10 and 20 ohms between 20 and 10,000 Hz. At 20,000 Hz, it fell to the rated 8 ohms.

Listening Performance. In a simulated live-versus-recorded listening comparison, the Rectilinear III was able to imitate our reference "live" music source with excellent



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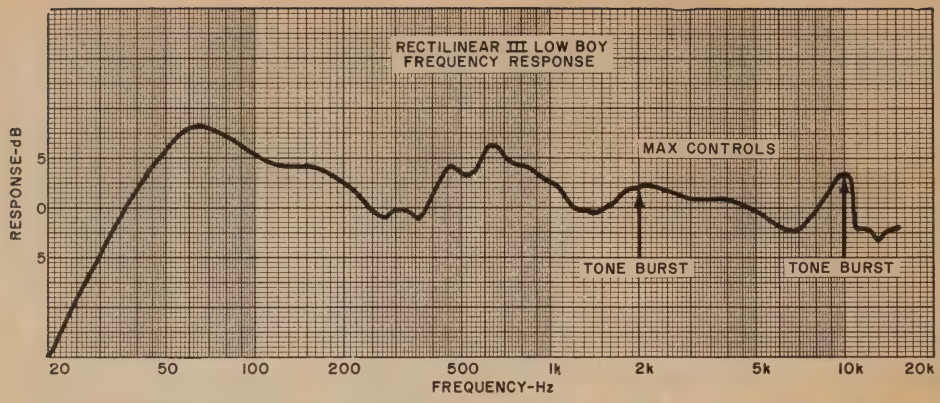

Transient response is shown by reaction to tone bursts (lower right) at 2 kHz and 10 kHz.

accuracy. In particular, the highest frequencies were radiated with the proper levels (a feature rarely found in most speaker systems) and with good dispersion. We would rate this speaker system among the best we have tested with this very sensitive indicator of overall fidelity.

The Rectilinear III Lowboy has an attractive oiled-walnut enclosure and a pleasant fretwork wood grille. Measuring 28″ × 22″ × 12¼″ and weighing 65 pounds, the Lowboy sells for $299. The standard version is slightly narrower and taller than the Lowboy and sells for $279.

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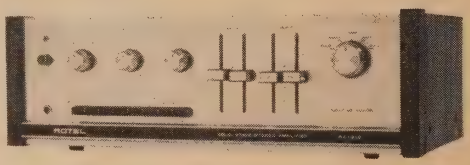
ROTEL MODEL RA-610 STEREO AMPLIFIER
(A Hirsch-Houck Lab Report)

THE Rotel Model RA-610 integrated stereo amplifier offers most of the operating flexibility and performance found in the most expensive control amplifiers but at the modest price of only $179.95.

At first glance, the control panel of the RA-610 is deceptively simple and uncluttered. There are three clearly marked knobs which are used to select the operating mode (normal and reversed stereo, either left or right input through both outputs, or the sum of both inputs through both outputs for mono listening), balance, and volume. Located to the right of these knobs are the tone controls, four vertical slider-type potentiometers which provide individual-channel control. Each slider pot has a slight detent for center set.

At the right of the front panel is the input selector which offers a choice of two magnetic phono inputs, tuner, and two additional high-level AUX inputs. The two phono inputs differ only in their impedances—50,000 ohms (for most magnetic cartridges) and 100,000 ohms.



A row of eight pushbutton switches along the bottom of the front panel controls other functions. There are two pairs of speaker outputs, each of which is switched in and out by its own pushbutton. A muting control button drops the amplifier's gain by 20 dB when activated (normal volume control settings are not disturbed when the muting network is switched in). There are separate high- and low-cut filters, a loudness compensation network, tape monitoring

function, and TONE DEFEAT—all push-button operated.

On the rear apron of the amplifier are located all the input jacks, tape recorder inputs and outputs (paralleled by a DIN-type connector), and separate preamplifier output/power amplifier input jacks. This last feature, found on an increasing number of quality amplifiers and receivers, is especially convenient for adding such accessories as a 4-channel decoder, active equalizer, or electronic crossover to a hi-fi system since it does not displace the normal tape monitoring function. Jumper plugs join the preamplifier to the power amplifier for normal operation.

The RA-610 amplifier also has individual speaker and line fuses and one switched ac outlet. The speaker connections are the easy-to-use spring-loaded type.

The power amplifiers of the receiver are direct-coupled to the speakers with balanced positive and negative power supplies. The amplifier is rated to deliver 32 watts/channel into 8-ohm loads with less than 0.1 percent IM and harmonic distortion.

Laboratory Measurements. On our test bench, the RA-610's harmonic distortion was only 0.075 percent at 1000 Hz and a power level of 1 watt (below the noise level at lower outputs). It dropped to between 0.05 and 0.06 percent at power outputs between 3 and 30 watts/channel with both channels driven into 8-ohm loads. Clipping occurred at about 30 watts, and IM distortion was between 0.3 and 0.5 percent for outputs between 0.1 and 30 watts. With 4-ohm loads, the output clipped at 36.6 watts, and with 16-ohm loads the maximum measured power was 19.7 watts/channel. It appears that the figure of 32 watts/channel that Rotel uses to rate this amplifier is either very slightly optimistic or, more likely, is based on only one channel being driven.

We measured the harmonic distortion throughout the audio frequency range at 30 watts/channel, finding that it was below 1.0 percent from 75 Hz to 5000 Hz, rose to 6.0 percent at 20 Hz, and was almost 10 percent at 20,000 Hz. This does not mean, however, that the amplifier has excessive distortion. On the contrary, what it does mean is that 30 watts/channel is not a realistic power rating with both channels driven. At half power (15 watts/channel), the distortion was between 0.05 and 0.10 per-

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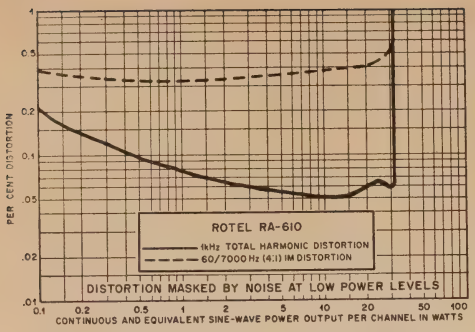
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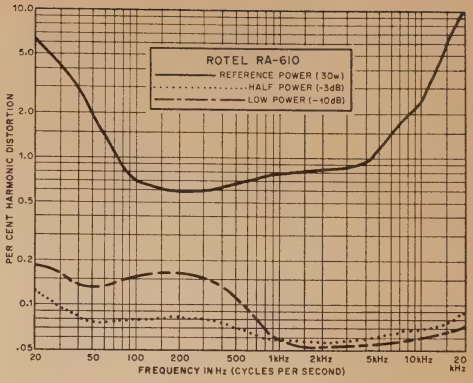

Distortion compared to output (above) and to frequency and power (at right).

cent over the entire 20-20,000 Hz range. At 3 watts/channel, a more common listening level, it was about 0.15 percent below 500 Hz and typically 0.05-0.08 percent above 1000 Hz.

The tone controls had good characteristics. The loudness compensation boosted only the low frequencies to a maximum of 11 dB at low volume control settings. The filters had a very gradual cutoff and did not attain their rated 6 dB/octave slope within the 20-20,000-Hz range. When both filters were switched in, the midrange volume dropped by 4 dB and the 3-dB response points fell at 100 Hz and 5000 Hz. The frequency response with the tone controls bypassed was flat to within 0.5 dB overall from 20 Hz to 20,000 Hz. The RIAA phono equalization was accurate to within ±0.8 dB from 30 Hz to 15,000 Hz.

The amplifier required 68 mV at the high-level inputs and 1.2 mV at the phono inputs for a 10-watt output. The corresponding noise levels were −75.5 dB and −72 dB, both very good and well below audibility. Phono overload occurred at 85 mV, a safe value for any good stereo cartridge.

Comments. The Rotel Model RA-610 integrated amplifier offers an attractive combination of control features and performance at a moderate price. Other high-quality amplifiers with similar operating features usually cost considerably more. At power outputs up to perhaps 25 watts/channel, the RA-610 compares very favorably with the best amplifiers.

The unit is unusually compact for an amplifier of this power rating; it measures 16¼" wide, 4⅞" high, and 8¾" deep.

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KOSS MODEL K2+2 QUADRAPHONIC HEADPHONES
(A Hirsch-Houck Lab Report)

FOUR-CHANNEL headphones would appear to be the creation of a jokester or cartoonist, conjuring up a picture of a two-headed audiophile. Nevertheless, they are quite real, as evidenced by the new Koss Model K2 + 2 "Quadraphones." Each earcup of the K2 + 2 contains two separate dynamic driver elements which are displaced toward the front and rear of the earcups. The 10-ft coil-cord supplied with the phones terminates in two standard stereo phone plugs; one black for the front channels, the other gray for the rear channels. As supplied, the plugs can be spaced about 9 in. apart, but if the amplifier's front and rear channel jacks are farther apart, a piece of tape joining the end of the cord can be cut and the plugs separated farther.

On the left earcup is a switch which parallels the two drivers in each earcup for normal stereo operation, driving them from

the front (black) plug. In the QUAD position, the switch places the drivers in a setup for 4-channel reproduction. Each earcup also contains a volume control for the front-channel drivers, providing the listener with a front-to-rear balance adjustment.

The phones are finished, for the most part, in black. The earcups are fitted with liquid-filled ear cushions which provide a tight, comfortable seal. The headband is padded with foam rubber, adding to listener comfort. The phones are relatively heavy, weighing 26 oz, less cord. Supplied in a sturdy plastic storage carrying case, the K2 + 2 phones are list priced at $85.00.

Lab Measurements. The frequency response of the phones was measured with the front and rear channel drivers parallel-connected for normal stereo operation. We used a flat "coupler" with a flush-mounted microphone and one-pound weight pressing the earcup to the coupler's surface.

The bass response of the phones was exceptionally powerful and was maintained down to 20 Hz with no sign of drop-off. Overall smoothness was considerably better than average for dynamic phones up to about 7000 Hz, beyond which the output fell off sharply. We made separate measurements on the front and rear drivers in the 4-channel mode. The two sections had similar characteristics at frequencies below 400 Hz, but at the higher frequencies, the output of the rear channel was down 5 to 8 dB relative to the front.

The tone-burst response was outstanding over the effective frequency range of the phones. Bursts were reproduced in essentially perfect form up to about 7000 Hz.

The phones delivered an acoustic sound pressure level (SPL) of 106 dB with 1.0 percent harmonic distortion at 1000 Hz, requiring a drive of 12.3 volts. With a test signal consisting of an octave of midband random noise, we found that 300 mW was needed to develop a 100-dB SPL. The isolation from external noise was very good.

Each earpiece had an impedance of 200 ohms which was quite flat over the entire audio range. In the stereo mode, with earpieces parallel-connected, the impedance was 100 ohms.

Comments. Compared to other good-quality dynamic phones, the K2 + 2's have very low efficiency. These phones take 10 to 100 times more power to provide the

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same SPL as most other phones we have tested. But this should pose no real problem with any amplifier rated at 15 watts or more per channel. Also, although the output at 1.0 percent distortion is somewhat lower than that of most other phones, it is still well over 100 dB and should be loud enough for most purposes.

In listening tests, as a standard stereo headphone, the K2 + 2 had the potent bass suggested by its response curve. We listened to these phones critically, comparing them to the Koss Model PRO-4AA's, one of the best dynamic phones available and one which closely resembles the K2 + 2 in size, weight, and general construction. The PRO-4AA definitely had a better high-end response, although its lows and midrange were quite similar to those of the K2 + 2. We would not describe the K2 + 2 as being deficient in highs, but we feel that a critical comparison against the same manufacturer's top stereo phones should be informative.

Obviously, one would not buy the more expensive K2 + 2 phones unless 4-channel listening was planned. Therefore, we listened to a wide variety of matrixed quadraphonic material and some ordinary stereo programs, using both the Sansui QR-6500 and Lafayette LR-440 4-channel receivers. Both models have matrix decoding circuits and the separate front/rear headphone jacks necessary for driving the new phones.

Can a true 4-channel effect be obtained with the K2 + 2 phones? Frankly, we are not sure. Often, there is a difference between the stereo and 4-channel modes of the K2 + 2's, but the subjective effect in no way resembles that obtained with speaker systems. With some sharply separated material, such as electronic music, there is a distinct sense of four directions. But—to us, at least—the "rear" channels seemed to come from *below* listening level. With 2-channel programs, even when processed by the matrix decoder for ambiance recovery, the difference between the two operating modes of the phones was usually negligible. Unfortunately, we did not have a suitable source of discrete 4-channel program material available; possibly the inherently greater separation of such programs would be more apparent through the K2 + 2 phones.

Summarizing, the Koss K2 + 2 is a well-built, good-quality stereo headphone that is —potentially, at least—able to exploit some of the unique characteristics of 4-channel sound while retaining full usefulness for 2-channel stereo listening.

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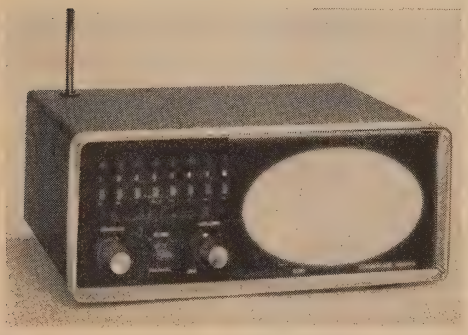
ELECTRA BEARCAT III MONITOR RECEIVER
(A Hirsch-Houck Lab Report)



MOBILE radio subscribers which include police and fire departments, taxi companies, etc., are the major users of the 30-50-MHz, 150-174-MHz, and 450-470-MHz Public Service/Business bands. In many urban areas, dozens of PSB channels are in regular use. Simple crystal-controlled FM receivers are adequate when you are interested in monitoring only a specific channel. However, where it is necessary to monitor a number of channels, automatic scanning monitors are the only practical receivers to use. Scanning monitors can be adjusted to scan a number of preselected frequencies rapidly and lock on to any channel on which a signal appears, while audio squelch circuits silence the receiver's output when no signal is present.

The Electra Bearcat III Model BC-3L/H, retailing for $139.95, is a compact automatic scanning FM monitor receiver. Measuring only 9″ × 6⅛″ × 3⅝″ and weighing just 5 lbs., the Bearcat III features a built-in 5″ × 3″ oval speaker. Power for the receiver can be supplied by any 117-volt ac source through its built-in ac power supply, or from any 12-volt dc, negative-ground mobile electrical system. Also supplied with the receiver is a mobile mounting bracket.

An external antenna, rated at between 50 and 75 ohms impedance can be plugged into a standard connector located on the rear of the receiver. However, in many fixed locations, satisfactory reception can be obtained with a short antenna which screws

into the top of the receiver and telescopes to 21".

On the front panel of the Bearcat III are eight red slide switches which are used for activating any or all eight of the preset crystal-controlled channels. The receiver scans at a rate of approximately 25 channels/second. Small light-emitting diode illuminators over each switch glow red when each channel is being scanned or received. When a signal is received, the LED for that channel remains lit until the transmission ends.

A three-position lever switch below the channel selectors establishes the operating mode for the receiver. In the upper position, the receiver automatically scans the channels. In the center position, reception is fixed on one channel. The lower position is spring-loaded; momentarily pushing down the switch allows the tuning to advance to the next channel.

A standard phono jack located on the rear of the receiver supplies an external 8-ohm speaker. With the external speaker plugged in, the built-in speaker is disabled.

Most of the inside of the receiver is occupied by a single printed circuit board assembly onto which one or two r-f front-end modules can be plugged. Separate modules are available for the three basic low, high, and ultra-high frequency bands. Up to eight crystals (available at $5.00 each), in miniature HC-18/U holders, can be plugged into the top of the PC assembly.

The front-end modules utilize field-effect transistor r-f amplifiers and mixer and are equipped with diode protection networks to guard against high r-f signal levels. An integrated circuit i-f amplifier is followed by two quartz crystal filter elements and a second IC which is used for gain, limiting, and detection. A single IC provides all audio amplification.

The scanning and LED circuits employ three more IC's and several transistors. A novel narrow-band afc system "pulls" the frequency of each crystal in the oscillator slightly to match the frequency of the received signal. This is an important consideration with the narrow i-f and discriminator bandwidth in this receiver.

Laboratory Tests. The Electra Bearcat easily surpassed its sensitivity specifications in our laboratory tests. It is rated to provide a readable output with a 0.25-μV input signal deviated 5 kHz, and a 10-dB signal-

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to-noise ratio with a 0.7-μV signal. Sensitivities on the uhf band (not included in our test unit) are slightly lower. We measured a 10-db S/N ratio at 0.25 μV, 24 dB at 0.7 μV, and full quieting (35-dB S/N) at 3 μV. The residual "noise" was largely power supply hum, not audible through the receiver's audio system.

The FM distortion of the 5-kHz deviation (400 Hz) signal was 5.6 percent, reducing to 1.7 percent at 2-kHz deviation and increasing to 6.2 percent at 6.5-kHz deviation. The maximum continuous output power, with an external 8-ohm load, was 1 watt; the 3-watt rating applies only to short-term transients of less than 15 milliseconds.

The frequency response rolled off at 6 dB/octave below 100 Hz and above 500 Hz. The latter was evidently the receiver's built-in standard deemphasis since there was no lack of highs in the received audio. The squelch could be set to trigger on signals as weak as 0.15 μV, while at minimum sensitivity a 1600-μV signal was needed to turn on the receiver.

The Bearcat III performed very well in actual operation. Using only the built-in telescoping antenna in a suburban basement location, we received numerous police and fire department stations up to 30 miles away. One of the channels in our test receiver was 162.55 MHz, on which we received a strong signal from the Weather Service transmitter located 25 miles away.

Circle No. 68 on Reader Service Card

HEATHKIT MODEL CO-1015 IGNITION ANALYZER

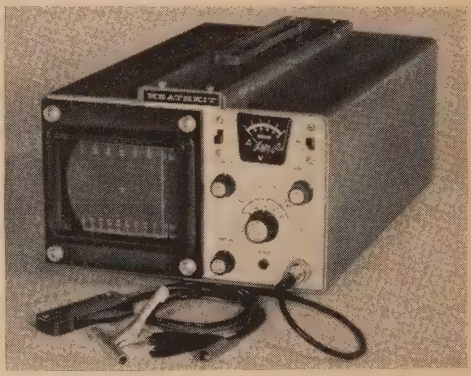
AUTOMOTIVE mechanics have in the past used such electronic devices as continuity testers and stroboscopic timing lights to diagnose automotive problems. Now, however, the professional and "weekend" mechanic has access to a high degree of diagnostic sophistication with Heathkit's new Model CO-1015 solid-state ignition analyzer which sells for $129.95 in kit form.

The ignition analyzer is an oscilloscope-type instrument which is equally at home in a diagnostic center and on the road. (For on-the-road use, Heath thoughtfully offers their optional $24.95 Model COA-1015-1 power inverter kit which, when assembled, mounts on the rear of the analyzer.)

The CO-1015 is so versatile an instrument that it is a virtual diagnostic center all by itself. It can be used with any standard or capacitive-discharge ignition system to check for shorted spark plugs, defective wiring, worn distributor parts, and incorrect dwell time. All of these tests can be performed on virtually any 3-, 4-, 6-, or 8-cylinder engine. In addition, the analyzer has a built-in meter-type tachometer which allows the user to make carburetor adjustments at the same time he is checking the ignition system.

The physical layout of the analyzer is simple and straightforward. The scope CRT occupies the entire left side of the front panel while the right side is given over to the controls, meter movement, and test cable connector.

To the left of the tach meter movement is the power switch. To the right is the



tach range selector; in HI, the meter indicates from 0 to 5000 rpm and in LO, from 0 to 1000 rpm. Below the power switch is the dual-function horizontal position control which, when pulled out, puts the CRT display in the "parade" or sequential mode. Below the tach range selector is the horizontal expansion control which is operated either in or out, depending on whether an 8- or a 6-cylinder engine is being tested.

A five-position function selector switch is located in the center of the front panel. This switch is used for displaying on the CRT screen the primary and secondary patterns for either standard or CD-type ignition systems. The center (CAL) position puts onto the screen a sine wave which is used for calibrating the display prior to testing the ignition system.

Assembly. Thanks to a well-written and illustrated assembly manual and neat interior

layout, the CO-1015 kit went together in less than ten hours. Once it was assembled, we connected the ignition analyzer to the appropriate points under the hood, using the information supplied in the manual to guide us. Incidentally, Heath supplies two extra manuals with the kit. One is a condensed version of a section in the assembly manual which illustrates all the waveforms likely to be encountered and explains exactly what is going on in both standard and CD ignition systems. The other covers complete engine data for vehicles up to 1971.

After locating the data for our test car in one of the manuals, we made the engine hookups as described. After allowing the analyzer to warm up and settle down, we had a look at the operation of the ignition system. We checked the pulses at both the primary and secondary sides of the coil. To do this, we first put the CO-1015 into the parade mode where all cylinder waveforms are displayed individually in a row. We noticed that one cylinder had a somewhat different waveform from that of the others. On the "superimposed" pattern, where all waveforms are displayed one atop the other, the seven good cylinders were reasonably alike, but the eighth, as might have been expected, was considerably different. Using the waveforms supplied in the manual to check this condition out, we determined that the maverick cylinder waveform was due to a bad sparkplug. Replacing this plug eliminated the problem.

We then checked the dwell which indicated that a small correction had to be made to the distributor. This change made the engine run a bit more smoothly.

Road Tests. A road test showed somewhat better performance than we had been getting. We then adjusted carburetion to obtain the suggested idling rpm for the engine in our make and model car.

Coupling the CO-1015 with a knowledge of the carburetion system of an engine gives the user a do-it-himself version of an electronic service center. For many car owners, having the CO-1015 on hand to check out and touch up their engines periodically could mean better performance, perhaps better gas mileage, and longer life for their "wheels." For the one- or two-man garage, the analyzer means more satisfied customers and a better ignition tuneup than anyone can do by eye or ear.

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Electronics and Car Thievery

By John T. Frye, W9EGV, KHD4167

IT WAS just nine o'clock when Mac heard the front door screen of the shop slam and looked up to see a puffing Barney coming through the service department door.

"Sorry I'm late, Boss," the redheaded youth apologized, scrambling into his shop coat. "I had a problem."

"I'm sure you did," Mac said sarcastically, "but let's hear about it."

"My uncle and aunt from Arizona stopped to see us yesterday on their way home from the East Coast, and we persuaded them to stay all night, although they were in a hurry to get home. We fed them a good breakfast at seven, and then I helped carry their luggage out to the car parked at the curb. That's when Uncle Willard discovered the only car keys were still in the ignition switch and all the doors had been carefully locked last night!"

"I'm sure you've solved that problem before with a coat-hanger shoved through the crack between the glass and the weatherstrip and used to lift the door locking knob."

"Yeah, that was my first thought, too; but I've got news for you: Uncle Willard had carefully unscrewed all those little knobs and had them in his pocket. That's his secret weapon, of which he's very proud, for foiling amateur car thieves. Every night, before locking up the car, he unscrews all those little knobs and takes them into the motel with him."

"Hey, that's kind of clever! What did you do then?"

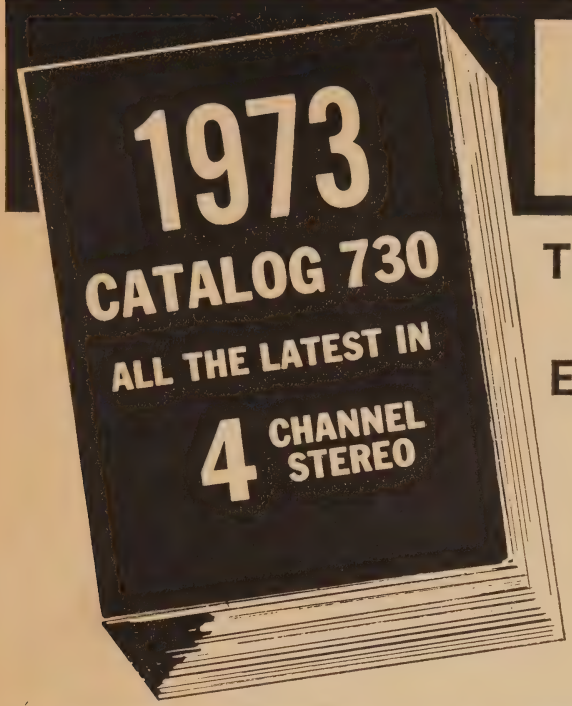
"Well, it wasn't easy to think with Aunt Virginia really psyching out poor Uncle Willard. I fiddled around with a piece of piano wire for a while, trying to get hold of a door handle, but that was no dice. On that car the padded arm rests project out so far you simply can't hook onto a handle. By this time Uncle Willard, spurred on by Aunt Virginia's needling, was all for taking a ball-peen hammer to a window glass, but I hated to see him do that to his brand new car; so I suggested we call the police and see if they could help.

"The desk sergeant was very sympathetic to our plight and said he would send someone out. It took a little while for the squad car to get there, but the two officers who came were very nice. They assured Aunt Virginia that Uncle Willard was not the first man—or woman—who locked the keys up in the car, and they admired his little business with the locking knobs. They had a whole mess of special car keys available to police departments, and they started trying them in the lock. It took a while, but eventually they found one that opened the door.

"While they were doing this, they gave us some very interesting statistics on car thefts in this country. Almost a million automobiles, or one out of every hundred registered automobiles, were stolen last year. That is twice as many as were stolen just six years ago. From 1960 to 1970, theft of accessories rose 69% while the theft of articles, other than accessories, from automobiles rose 131%. I'll bet that when we get the figures for 1972 we'll find the theft of tape recorders has boosted one of those figures tremendously."

"Maybe that increase comes from there just being more cars."

"I suggested that, but the police say no. The increase in car thefts over the ten year period was four times greater than either the increase in car registration or the increase in population of the 15-24 year old



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age group—the group, incidentally, that accounts for the majority of car thefts. The rate of car thefts is much greater in large cities, where 1,117 thefts per 100,000 population occurred in 1970. This compares with 288 suburban and 71 rural thefts per 100,000 population. However, 'percentagewise,' the recent increase in suburban car thefts is much greater than in the cities; so maybe we're going to catch up."

"How are the police doing with these thieves?"

"Not so hot. 77,448 cars were stolen in New York City in 1968, and 7166 arrests for car theft were made. 94,835 cars were stolen in 1970, and only 6,539 arrests were made. This is not too surprising since most thefts occur in residential sections at night with no witnesses. Incidentally, the thefts peak up in the fall, with October being the worst month. While eventually 84% of the stolen cars are recovered, they are often abandoned only after being stripped, wrecked, or mechanically abused. It seems to me," Barney concluded, "that electronics should be doing more than it is to help with this problem."

"I agree," Mac said. "There's more to it than just the money loss of the stolen cars. A car stolen for a joy ride is often the first step a youngster takes towards a life of crime. A 1970 survey showed 77% of those arrested for auto theft were under 21, and over 400 cars were stolen by children under 10! It's estimated the driver of a stolen car is 200 times more likely to have a traffic accident than is a person driving his own car, and one out of every 90 traffic deaths involve a stolen car. A stolen car is often an instrument in other crimes. In fact, auto crime now makes up one-fifth of all crime committed in the U.S."

"Hey, you've been talking to the police, too!"

"No, I've just been doing some reading so I can pressure my state legislator into passing a no-fault auto insurance bill. I'm sick of paying constantly climbing insurance premiums.

"But I think the auto industry has a responsibility in this area that it has only recently made much effort to meet. It introduced the steering column lock on 1970 models; and now the theft of one, two, and three year old models is dropping off while the theft of older cars is climbing. Unfortunately, these newer cars are being harder hit by professional thieves who take spare tires, batteries, radiators, alternators, and other items from the trunk or engine compartment. If they can't steal the whole car, they just take parts.

"Worse yet, assault is climbing. If the thief can't steal the car without a key, he tries to take the key away from the owner. So what we need is a system that will protect against theft of the car as a whole, theft of items in the trunk and beneath the hood, and assault against the passenger inside the car.

"Probably the auto industry feels that security doesn't sell any better than safety. That explains why, until very recently, all electronic anti-theft devices on cars were developed in the 'after-market.' By that I mean they were add-on devices designed and marketed by people entirely outside the auto industry. I well remember the first such device I saw. Doc Eberts, the druggist, had it on his new Packard. It consisted of a little copper ring surrounding a metallic pendulum mounted up under the dash. The ring could be adjusted so the bottom of the pendulum rested in its center. If anyone tried to enter the car or even shook it, the pendulum oscillated; and every time it touched the ring the horn blew. The alarm was armed and disarmed by a concealed switch outside the car. This system, of course, had several drawbacks: kids got onto it and drove Doc nuts by jumping up and down on the bumper to make the horn blow; movement of the car by a strong wind would sound the alarm; it was very easy to forget to arm the alarm on leaving the car or to disarm it before trying to enter."

"Someone was trying, anyway," Barney observed. "It's not easy to install anything of that nature after the car is built. There's no place to run wires where they won't be seen. To get around this, some systems offered take advantage of existing wiring. For example, at least two of them trigger an alarm whenever there is a sudden slight drop in battery voltage, such as occurs when an opened door operates a courtesy light or when the ignition or headlights are switched on. A gradual decline in battery voltage, such as normally occurs after the car has been operated, will not set off the alarm. This kind of device is easy to install on any car because all you have to do is mount the components and make a connection to the electrical system."

"I know, but none of these add-on de-

vices seem to have very wide acceptance," Mac said. "Fortunately at least one auto manufacturer is offering a sophisticated anti-theft system installed at the factory. I refer to the new Chrysler Electronic Security Alarm system that will be available on all standard size Chrysler-built cars starting in 1973. The system is built right into the car's basic electrical system and reacts with visual and audible alarm signals whenever the passenger, trunk, or engine compartment is forced open or there is an unauthorized attempt to start the car. Moreover, the system serves as an occupant distress alarm and provides instant protective locking. When an emergency button on the instrument panel is pushed, all doors are instantly locked, the hood latch is blocked, the horn starts pulse-type blowing, and the headlights, tail lights, and front and rear marker lights flash on and off. If the door, trunk, or hood is forced open and then closed, this alarm continues for three minutes before subsiding until another attempt to enter is made. If the door is left ajar, the alarm sounds until the battery runs down.

"The system is armed automatically when the door is locked with the key, and it is disarmed when the door is unlocked with the key. Any bypassing of the ignition switch so the motor is started without the key starts the alarm sounding."

"How does the system work?"

"It would not be advisable to go into detail about that, but I can tell you the heart of the system is a well-concealed and protected control box equipped with power relays, integrated circuits, transistors, resistors, and capacitors. This box receives a message from any sensor, interprets the message, decides which of several courses of action is appropriate, and initiates that action."

"Sounds like a pretty thoughtful piece of engineering," Barney said, "and I imagine other auto manufacturers are going to follow suit. Electronics has already shown what it can do in the protection field for the home and factory. It is high time the auto industry turned to electronics for protecting their products from thieves. But I never would have believed that Uncle Willard's locking up his car keys would have furnished all this food for thought and conversation!" ◈

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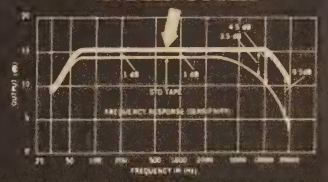

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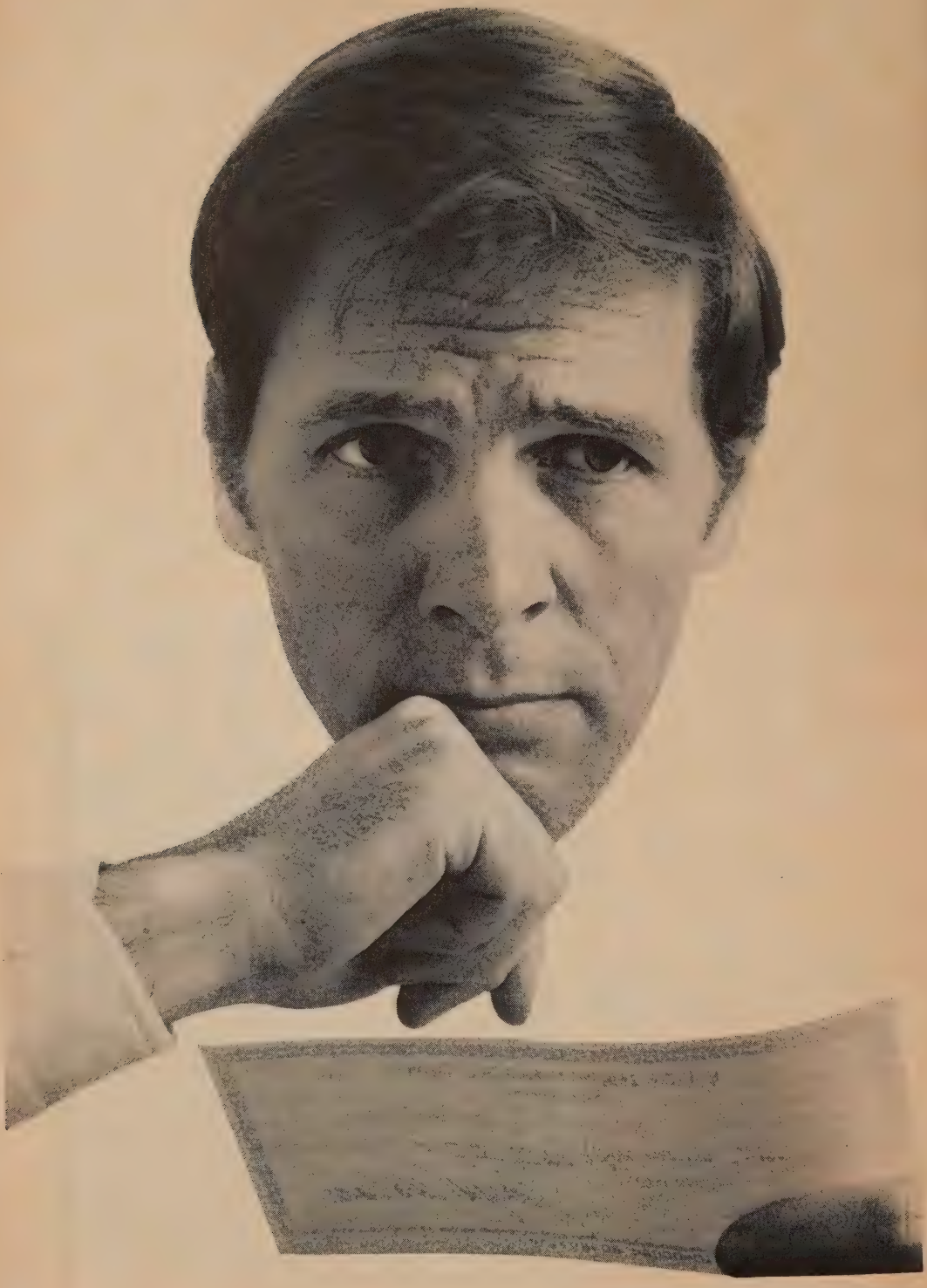

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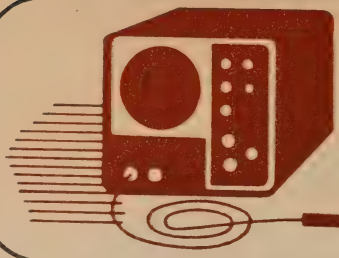

Test Equipment Scene

By Leslie Solomon, Technical Editor

Power Supplies—Power to the Circuit

WHEN solid-state devices were introduced, there was an almost immediate increase in the design and use of battery-operated equipment. Convenient as this trend has been, battery-operated solid-state circuits still develop faults and it is not always advisable to use batteries to analyze and correct circuit failures. After realizing that the batteries used may be run down or damaged by the short circuit that caused the original trouble, most technicians look for a power supply to use in testing.

Unfortunately, many of us think that a power supply consists merely of a transformer, a rectifier and a couple of filter capacitors. So what if the voltage is a little above or below the required amount—power is power! In most cases, we don't even know whether the home-made supply can deliver the current needed; and, what is worse, as the circuit under test demands more current, the output voltage from the makeshift supply drops drastically. Then there are the power line variations which can cause a power supply's output to wander considerably.

Obviously, what most of us need is a power supply whose output voltage can be set precisely with the assurance that it will not wander with changes in load or input. It should deliver enough current to supply the circuit under test yet it should not deliver an excessive current that could "cook" faulty components and cause damage to PC boards.

Power Supply Specs. Here are some of the important specifications that must be considered when designing or choosing a power supply. The first is the adjustable voltage output; and you can get supplies with variability from zero to 50 volts. (For vacuum tube circuits, supplies that go up to 400 volts are available.) Many supplies have switchable ranges for flexibility.

Approximately the same things can be said about the current rating. Current ranges are available from about 100 mA to several amperes, or more. Of course, the flexibility and variability of the voltage and current ratings determine the complexity and, therefore, the price of the supply. If you are considering buying a commercial (or kit) power supply, don't skimp on ranges and keep in mind future requirements for voltage and current. You can always crank a supply down; but making it deliver more voltage or current presents problems.

There are two types of regulation to be considered in choosing a supply: line and load. Line regulation is specified as a percentage of the preset output voltage variation as a result of a certain amount of change in the line voltage. For example, line regulation may be given as "x% change in output from 105 to 125 volts ac input," or "x% change in output for x% change in line voltage." Obviously, the percentage change in output as a result of input variations should be as low as possible.

Load regulation is specified in terms of the amount of output voltage variation (as a percentage of full-load voltage) when the load is varied from no load to full load.

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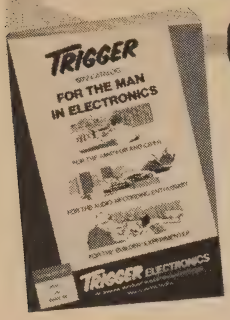

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The variation should, of course, be as low as possible. Ripple and noise are usually expressed as "so many milli- or microvolts maximum," and should also be as small as possible.

Output impedance is a specification that most experimenters don't take into consideration; yet it is very important. If all the current required for a test comes from the same power source, and if that source has a high internal impedance, then you are deliberately inserting a resistor in series with the supply and the circuit being tested. The various circuit currents flowing through this "phantom" resistor produce all sorts of voltage drops, and the result may be circuit oscillation, motorboating, or distortion. These are all produced by mixing a number of different signals generated across the same resistor.

The output impedance of a power supply should be as low as possible and is usually expressed as "so many ohms from dc to some frequency." In this case, the frequency range should be as broad as possible.

Metering is a matter of choice. It is always better to have a built-in panel meter to indicate the output voltage or current without having to resort to outboard VOM's and their associated lead problems. Many supplies have two meters (voltage and current), while others use a single switchable meter. In any case, a clearly marked meter is worth the small extra price.

It is best to purchase (or build) a supply having a controllable current output. This limits the amount of current in the circuit and, in the event of a short, will prevent further circuit damage. The supply itself will also be protected against damage. A front-panel control will enable you to "dial in" the current required by the circuit. This permits you to compare the amount of current needed with that normally required or as given by the manufacturer's specs. You can also use the current setting to determine what batteries you should be using.

If you do a lot of work with automotive or boat electronics (CB gear and the like), you should have a 12-volt, high-current power supply or battery. In this case, take a look at the various power supplies that can be used for battery recharging. Some have automatic shutoffs when the battery is fully charged. They are protected against accidental polarity reversal and can be left permanently connected to the battery. Such

a supply serves a dual purpose in that it can be used as a variable-voltage bench supply as well as a battery charger.

Who Makes What. There are quite a number of bench power supplies available, both in kit and wired forms, with prices to please everyone. You will find them on your favorite distributor's shelves or in catalogs. Heath, for example, has solid-state supplies with outputs from zero to 50 volts and 1.5 amperes. They also have a 400-volt, 100-mA supply for vacuum-tube circuits, and a battery charger. Except for their lowest priced unit, meters are employed.

Eico has solid-state supplies with ratings up to 30 volts and 300 mA; a 400-volt, 100-mA supply and two battery chargers. Sencore recently announced a supply that goes up to 30 volts and 20 amperes, making it a double threat as supply and battery charger. RCA also has several supplies ranging to 20 volts and 200 mA.

Then there is a line of commercial or industrial power supplies. These are more expensive than the usual hobbyist and technician types; but if you can afford, them, they are quite good for laboratory use.

Future Plans. One of the biggest difficulties with power supplies is their physical size—caused by the big filter capacitors, the transformer, and the heat sink usually required for the regulator transistor. The latter also means that the heat dissipated is power that you are paying for and wasting.

A new technique is now being investigated by many manufacturers. In this approach, the power from the line is rectified with a simple circuit which drives a high-frequency power oscillator, whose output is again rectified and filtered. At the high frequency (tens to hundreds of kHz compared to the 60 Hz of the power line), filter capacitors, transformers, and heat sinks can be much smaller. New rectifiers (such as Schottky diodes) contribute to the reduction in size of the heat sinks.

A typical power supply capable of delivering 50 volts at 20 amperes is about ¾ cu. in. per watt. Of course, the introduction of new semiconductors such as CMOS (Complementary Metal-Oxide Semiconductor), with relatively minute power requirements, will hasten the trend toward more efficient, smaller, cooler, and cheaper power sources. ◈

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Communications Scene

By Richard Humphrey

Search and Rescue Network

"THERE was a man down in French Guiana who had his legs crushed," says Lieutenant Armand Chapeau, Rescue Coordination Center Controller in Miami. "He was a Japanese seaman on an American fishing vessel and he was in a French hospital. He had to have artificial arteries and the nearest place the job could be done was in Miami."

Then the world-wide search and rescue communications network sprang to life to help the man. Lieutenant Chapeau continues his story:

"We contacted Washington by telephone and on through to Panama. From Panama the message went to Paramaribo in Surinam by radio, by commercial telephone to the French hospital. At the same time we advised the American vessel of the status by radio from a French radio station. We got a C-141 diverted from an Embassy run to Rio de Janeiro to pick the man up. He was brought by private aircraft to Paramaribo where the C-141 flew him to Miami."

Almost as an afterthought, Chapeau concluded: "We only had 24 hours to get him to the Miami hospital or he would have lost his legs."

Missions of Mercy. There have always been missions of mercy like this; but during the last decade, all the various international agencies, organizations and groups dedicated to SAR—Search & Rescue—have been slowly and securely welded into a brotherhood speaking a common language and practising a common craft. And the tool most effective in this work is communications. Communications by telephone, teletypewriter, cable, and radio. These communications frequently cost tens-of-thousands of dollars and many man-hours in saving one life.

But all this investment would mean nothing if everyone in the search and rescue community were pulling in different directions. This is where what might be called an International SAR Plan comes in. The idea is to "provide the various military services and civilian agencies a common procedure for search and rescue operations, so that any military and civilian combination can effectively accomplish search and rescue missions." (*National SAR Manual 1959*)."

Leading in this effort to create a world-wide SAR means-of-communicating is the National SAR School (Governor's Island, N.Y.). As of May 5, 1972, 1355 SAR specialists had been graduated—mostly from the Air Force Aerospace Rescue & Recovery Service and the Coast Guard. In addition, there were 74 representatives from 22 foreign countries.

Computerized Network. Helping to make the job easier is a sophisticated computerized teletypewriter network called AUTODIN (Automatic Digital Network) which handles military and national security traffic along with SAR messages. AUTODIN is already using satellite relay (expected to be 100% satellite relay by 1975) and automatically breaks any message down into *Flash, Immediate, Priority or Routine* with a high classification immediately interrupting a lower.

SAR forces throughout the world also use commercial Telex, the international dial teletypewriter service that has over 50,000 subscribers. For instance, such diverse groups

as Japan's Maritime Safety Agency, the *Deutsche Gesellschaft Zur Rettung Schiffbruechiger* and the Polish Ship Salvage Company (that nation's SAR service) can be reached quickly by the U.S. Coast Guard or the Aerospace Rescue & Recovery Service. Recently, the USCG Eastern Area Command Rescue Coordination Center in New York unnerved visitors from Russia's Aeroflot by putting them in contact with Moscow in ten minutes.

Another world-wide teletypewriter system available to SAR groups is the International Civil Aviation Organization's Aeronautical Telecommunications net. The ICAO was founded primarily to provide safety and navigational facilities for the North Atlantic air travel routes. This organization is also responsible for the Rescue Coordination Centers in almost every country in the world and the Ocean Station Vessels dotting the Atlantic and Pacific Oceans.

In the U.S. there are two teletypewriter networks dedicated solely to SAR: SARLANT (Search & Rescue Atlantic) and SARPAC (Search & Rescue Pacific). No other traffic than SAR is carried by these two systems which, of course, can be linked to any international system. One domestic-international hook-up used frequently is SARLANT or SARPAC into the Navy Teletypewriter Exchange Service (NTX) to give stateside SAR groups direct contact with such far-flung radio stations as NMR (USCG, San Juan), NBA (USN, Balboa), CTE (USN, Azores), 13 Canadian SAR radio stations, EAC (Cadiz), EAT (Tenerife) and EAF (Vigo), all in Spain. The NTX network also links two USCG radio stations in the Pacific as well as three Navy stations, seven Japanese, four in New Zealand, one in French Polynesia and KUQ in fabled Pago Pago.

Finally, the individual military services have their own teletypwriter systems which are available for SAR traffic. This includes the ASW (Anti-Submarine Warfare) net plus some classified nets.

Telephone and Radio Systems. Telephone systems used in search and rescue are as extensive as the teletypewriter services with the emphasis on "hot lines". One—SARTEL (Search & Rescue Telephone)—is reserved exclusively for SAR traffic. Another is the Federal Telephone Service managed by the General Services Administration. The FTS is leased from Bell Telephone. The telephone equivalent of AUTODIN is AUTOVAN (Automatic Voice Network), a world-wide dial system with priority programming (like AUTODIN). In addition, SAR forces make use of leased "hot lines," leased tie-lines, military leased lines and, of course, Bell Telephone.

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	Safety
156.8 MHz	International maritime FM (Distress frequency in American waters)
6204 kHz	International Asian from 35°S to 30°N & 120°W to 60°E
	Control Channels
3023.5 kHz	International voice
5680 kHz	International voice
	On-Scene Channels
3023.5 kHz	International voice/CW, USB
5680 kHz	International voice/CW, USB
121.6 MHz	U. S. SAR Units, world-wide voice
123.1 MHz	International (except U. S. and Canada voice
282.8 MHz	U. S. SAR Units, world-wide voice
	Homing Channels
410 kHz	International maritime direction finding, CW/MCW
514 kHz	Japanese area only, voice/CW
522 kHz	World-wide, voice/CW
532 kHz	World-wide (except Japan), voice/CW
1742 kHz	Pacific Aerospace Rescue & Recovery Service air-to-air only CW/MCW
1746 kHz	Pacific Aerospace Rescue & Recovery Service air-to-air only. CW/MCW
	Alarm, EPIRB, Datum Channels
500 kHz	MCW, distress alarm is 12 4-second dashes separated one second
2182 kHz	MCW, distress alarm is alternating tones of 2200 Hz and 1300 Hz, each tone ¼-second duration
121.5 MHz	MCW, downward sweep of at least 700 Hz between 1600 Hz and 300 Hz repeated 2-3 times-per-second
243.0 MHz	"
240.6 MHz*	"
261.3 MHz*	"
275.1 MHz*	"
282.3 MHz*	"

*For Datum Marker Buoy use to mark search areas.

It's in radio communications, however, that search and rescue groups all over the world have made their major investment. And it's amazing how many countries make use of the radio amateur and 27-MHz Citizens Band frequencies and equipment. While both the U.S. Coast Guard and the Aerospace Rescue & Recovery Service make use of hams and CBers on infrequent occasions, the Coast Guard has consistently refused—for many good reasons—to make the 27-MHz band a search and rescue tool.

But Venezuela and Bolivia are among the many South American nations which include amateur stations as an integral part of SAR. Chile, for instance, maintains stations on 40, 20 and 15 meters in its four Rescue Coordination Centers (Autofagasta, CE1AB; Santiago, CE3AJ; Puerto Montt, CE7AG and Punta Arenas, CE8AD). Holland, France and Finland, among others, use the 27-MHz Citizens Band permanently.

International Distress Frequencies. The bulk of international SAR communications is, of course, on the various international distress frequencies of 500 kHz (CW), 2182 kHz (voice), 8364 kHz (survival craft, CW), 121.5 MHz (aircraft, CW/voice) and 243 MHz (survival craft and U.S. Military aircraft, CW/voice). In American waters, vhf channel 16 (156.8 MHz) is also a distress frequency.

Besides the international distress frequencies you'll find search and rescue traffic on the SAR *control,* SAR *on-scene* and SAR *homing* frequencies listed in our table. Expanding the maritime and aeronautical safety network, all marine coastal and vessel stations, and land and aircraft stations are required to monitor the international distress frequencies covered by their equipment.

This world-wide surveillance on the various distress frequencies is augmented by the increasing use of EPIRB's—Emergency Position Indicating Radio Beacons. EPIRB's are battery-powered MCW (modulated continuous wave) transmitters either activated manually or by a water-soluble plug switch. Once released by a vessel or aircraft in distress, the EPIRB will broadcast a distinctive signal for several hours, usually on 121.5 MHz. EPIRB's operating on 2182 kHz are effective except in American waters where congestion and interference tend to bury the milliwatt signal. There are presently over 150,000 EPIRB's in use, mostly on commercial and military aircraft. The Japanese have the most comprehensive EPIRB coverage on vessels with between 12,000 and 15,000 operating on 2091 kHz. The FAA recently changed the EPIRB acronym to "ELT" (Emergency Locator Transmitter). Other SAR groups are expected to conform shortly.

Along with practically everything else in the world, SAR communications has been partially computerized. And for once, computerization is working the way it's supposed to: quickly and accurately. AMVER—the Automated Mutual Assistance Vessel Rescue System—is a voluntary program open to ships of all nations. It is operated by the USCG AMVER Center on New York's Governor's Island which uses a "master" computer in Washington. All vessels registered with AMVER (nearly 6,000 as of January 1, 1972) are tracked from the beginning to the end of their voyages. In case of an emergency—a seaman suddenly brought down by appendicitis, for instance—the radio operator can contact AMVER and, in a matter of minutes, receive a list of vessels with doctors aboard in the area requested. The list is in a nearest-to-farthest sequence and gives the vessels' names, radio callsigns, positions, courses and speeds as well as other pertinent information.

But all the computerization and communications in the world would be of little value if cooperation among the search and rescue organizations didn't exist. It might even be said that cooperation, instead of communications, is the backbone of SAR. This international SAR cooperation is furthered by the International LifeBoat Conferences held every four years with a different country as host; by the World Administrative Radio Conferences of the International Telecommunications Union approximately every seven years; and, on a continuous, practical level, by the National Search & Rescue School with its intensive 4-week courses on all aspects of inland and maritime search and rescue.

This emphasis on cooperation is followed by many other international bodies concerned with safety of life and sometimes creates some strange situations. It's a little known fact, for instance, that during the time the USA denied that Red China even existed, we were exchanging daily weather information with Peking. And, just like the weather, search and rescue knows no international boundaries. ◈

As modern hospitals get more electronic gear, electronics technicians are needed to take care of it

THE MEDICAL ELECTRONICS TECHNICIAN

A Vocational Profile

BY JOHN H. HOLMGREN
Assistant Administrator
St. Joseph Hospital
Wichita, Kansas

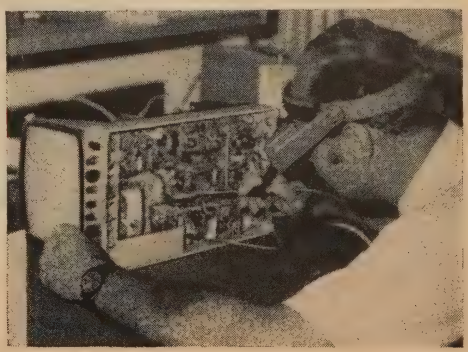
THERE is a new member of the hospital staff—one who works behind the scenes but is playing an ever more important role in the use of modern, complex medical electronic systems. He is the electronics technician (ET, for short), and his job covers all of medical electronics from preventive maintenance, emergency repair, and installation of a wide variety of electronic elements, to keeping up with the latest developments in this fast-growing field.

His job is not an easy one. Many ET's are on call 24 hours a day, 7 days a week (usually via a radio paging system) and they often have to solve a relatively complex problem in a very short time. As Dale Mason, an ET as St. Joseph Hospital, puts it, "I am at the hospital during normal working hours, averaging about 15 calls per day from departments needing electrical or electronic help—either emergency or routine maintenance. Since my electronic pager reaches out about 30 miles from the hospital, I take it home with me for emergency contacts." The salary? It can vary from $10,000 to $12,000 and up, depending on the region and the hospital.

The ET program at St. Joseph has been a success from its initiation. Bernard Keegan, Director of Material and Plant Services, says, "The electronics technician was originally hired to maintain the electronic equipment in coronary and intensive care units. His activities in this area alone have resulted in savings in maintenance and repair costs over and above his salary. He also does excellent work in inhalation therapy, the emergency room, physical therapy, and in the laboratory."

Diversified Duties. The electronics technician has many different jobs to perform—though they are centered on the repair and maintenance of all types of electronic equip-

Dale Mason, electronics technician, checks a hospital CCTV monitor unit.



ment. On many occasions, he must instruct lower-grade maintenance personnel in advancing their electronics skills; and quite often he helps train nurses, therapists, and doctors in the technical aspects of the equipment—especially with regard to safety standards.

Among the items to be repaired and maintained are arrythmia recorders, ECG amplifiers and recorders, defibrillators, single, dual, and multichannel scopes, heart-rate meters, remote heart-rate modules, grounding systems, various types of telemetry systems, nurse alert systems, and emergency power units. Most of these elements relate to coronary and intensive care units.

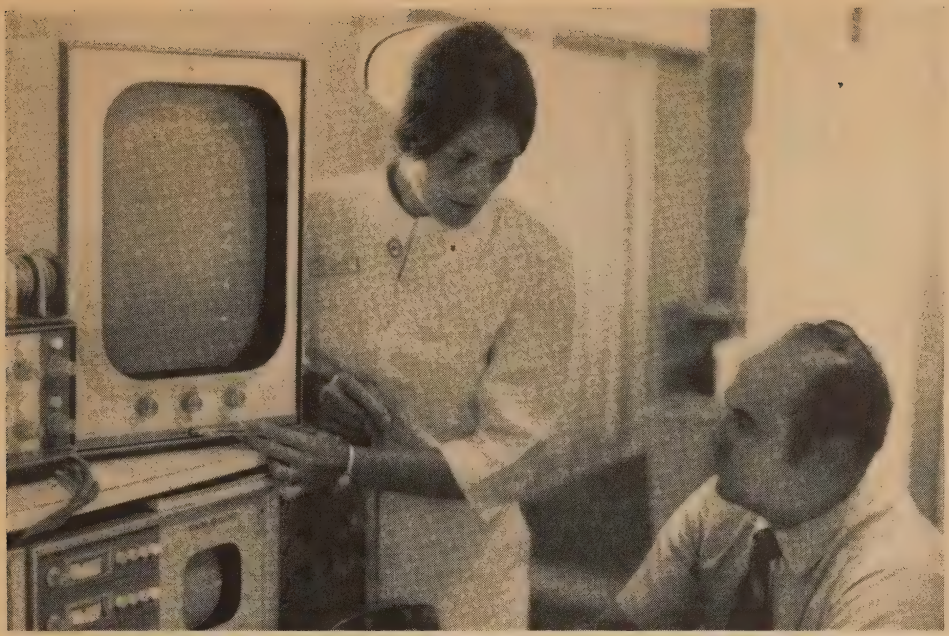
In surgery, there are ultrasonic washers, ground-detection systems, cardiac-monitor transducers and display consoles, and conductive floor testers. The physical therapy department has diathermy machines, electronic stimulators, ultrasonic generators, and traction machines for the ET to take care of. And in the hospital generally, there are many communications systems, including CB and commercial two-way radio systems, monitor receivers, paging systems (both r-f and induction), and associated antennas.

There is also quite a bit of TV equipment in most hospitals—aside from that installed by vendors in patients' rooms. There are closed-circuit systems, both color and monochrome, monitors, tape recorders, and cable

HOSPITAL ELECTRONIC/ ELECTRICAL EQUIPMENT

- Analytical photometers
- Cardiac pacemakers
- Civil defense radio equipment
- Closed circuit television
- Conductivity meters (still)
- Diathermy machines
- Electric beds
- Electrocardiograph machines
- Electrocardioscopes
- Electroencephalograph machines
- Electromyograph machines
- Electronic nebulizers
- Electronic thermometers
- Electronmicroscopes
- Electrophysiological instruments
- Electrosurgical instruments
- Heartrate meters
- Laboratory apparatus
- Monitoring equipment in surgery
- Ohmmeters
- Operating room tables
- Oscilloscopes
- Paging systems
- Pulmonary function machines and respiratory monitors
- Resuscitators
- Sigmoidoscopes
- Static charge meters
- Telemetry systems for recording physiological signs
- Ultrasonic machines
- Ultrasonic reflectoscopes

Here, the electronics technician and registered nurse are shown checking a patient's progress on the remote control board of the coronary care unit at a large hospital.



The electronics technician handles many complex monitors such as this seven-channel cardiac system. He and a registered nurse are shown discussing operation of device.

distribution circuits. There may also be a CCTV patient-bed availability system which includes a number of large and small video monitors, a control station, a memory generator unit, etc. And in many cases, the hospital public address and music system comes under the aegis of the electronics technician.

Besides doing the actual maintenance and repair, the ET may also be called upon to develop specifications for certain types of electronic gear, coordinate vendor installed equipment, and check and accept any system after installation.

Training Required. An ET should have vocational training from an approved electronics school (or equivalent training in the military services) and experience in servicing a diversified range of electronic equipment—from multi-transistor radio or TV through complex monitoring or diagnostic machines such as those used in industry. Usually, an ET has had experience in an industrial or commercial electronics company, has installed aircraft or marine electronics, or has worked in a military or consumer radio/TV service shop.

World of the Future. The ET has a wonderful chance to see the world of the future in medical electronics. For example, the National Heart and Lung Institute is presently contracting for telemetry devices to be worn by physically active, healthy people on a 24-hour basis to establish a monitoring or diagnostic measurement procedure for potential cardiacs. Several companies are developing such systems—and other telemetry gear to keep an eye on patients up to 1000 ft away from the monitoring console. Such a system, developed through the experiences of the NASA space programs, uses the very latest in electronics technology.

The ET may also be called upon to attend technical discussions with leaders in the industry, covering all types of sophisticated equipment—much of which is the very latest, both in circuit design and component usage. He may also be involved in discussions covering intensive care and coronary procedures, becoming an advisor to hospital management in product review, source selection, and observance of instrument safety standards.

In general, the ET's capabilities and potential in the modern hospital have just begun to make an impact, and will become far more important in the years to come as even more complex electronic equipment (including computers) takes its place beside the doctor. ◈

FISHER 2/4-CHANNEL RECEIVER

A new line of advanced 2/4-channel receivers has been introduced by *Fisher Radio*. Among these is the Model 404 which features a large back-lighted linear dial scale, two meters for optimum tuning, slide-type tone and master volume controls, and a "joystick" balance control that permits individual level adjustments of any channel. The latest integrated circuit, MOSFET phase-locked loop, and hybrid module technologies are incorporated into the receiver.

Circle No. 70 on Reader Service Card

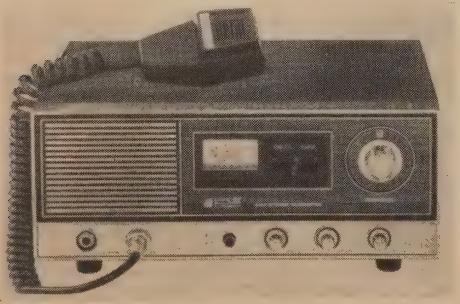
3-HOUR CASSETTE FROM TDK

The industry's first three-hour cassette—the TDK C-180LN—has been introduced by *TDK Electronics Corp.* TDK's unique high-density magnetic coating, special tape backing material, and binder system are said to provide a strong, magnetically superior tape only 0.025 mils thick. The tape, combined with the company's jam-proof cassette mechanism, makes three-hour cassettes feasible for the first time. The C-180LN plays for 90 minutes in each direction, making it 50% longer than any other cassette on the market.

Circle No. 71 on Reader Service Card

PEARCE-SIMPSON CB BASE STATION

Pearce-Simpson is currently marketing a new 23-channel CB base station designated the Lynx 23. The 2-way radio features delta tune,

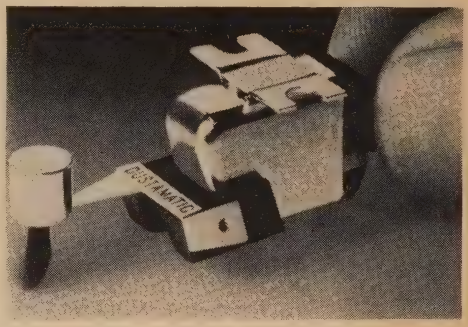


117-volt ac/12-volt dc power supply, and an extra large S/r-f/modulation meter. The meter is designed to glow amber when the rig is receiving, red when transmitting, and bright red when transmitting with modulation. Also included is Pearce-Simpson's latest innovation, a variable preamplifier which saves the cost of expensive gain-type microphones.

Circle No. 72 on Reader Service Card

PICKERING STATE-OF-THE-ART PICKUP

Pickering has developed a new top-of-the-line, state-of-the-art stereo pickup to meet the demands of the most sophisticated listener, one who has components of such superb quality that the new XV-15/1200E cartridge is a necessity. The cartridge's 1200E designation comes from the fact that it has a dynamic coupling factor of 1200. Among the pickup's specifications are a



frequency response flat from 10 to 30,000 Hz, tracking force of ¾ gram (+⅛/−¼), and a stylus radius of 0.0002″ x 0.0007″ elliptical.

Circle No. 73 on Reader Service Card

PHILIPS ELECTRONIC TURNTABLE

North American Philips Corp. has introduced a servo-controlled electronic turntable (Model GA 212) supplied with a tonearm and a hinged dust cover. The dc-powered manual 33⅓-/45-rpm turntable employs independent controls for precise speed calibration regardless of voltage, frequency variation, or tracking force. Capacity switches are used for speed selection and stop; automatic shut-off is accomplished with a photoelectric switch; and tonearm cueing is via a rocker bar. The generator motor and belt drive system filter out vibration and rumble, while millisecond correction for drift, wow, and flutter is constantly compensated by a minicomputer electronic brain.

Circle No. 74 on Reader Service Card

REALISTIC 3-BAND MONITOR RECEIVER

The new Realistic Patrolman PRO-3A vhf/uhf 3-band monitor receiver introduced by *Radio Shack* is designed to tune the 30-50-MHz and 152-174-MHz vhf bands as well as the 450-470-MHz uhf band. It features an extra IC in the i-f stage for improved selectivity, full-wave bridge rectification for better power regulation, an

added stage in the uhf buffer amplifier for greater clarity, and six added solid-state devices for improved overall circuitry. A mounting bracket is supplied for mobile use. The PRO-3A operates on either 117 volts ac or 12 volts dc and will automatically switch to battery power in the event of an ac power failure.

Circle No. 75 on Reader Service Card

SHERWOOD AM/STEREO FM RECEIVER

The *Sherwood Electronic Labs., Inc.*, Model 7200 AM/stereo FM receiver employs direct-coupled amplifier output circuitry, field-effect transistors, and ceramic FM i-f filters. It is rated at 150 watt (IHF) output, or 40 watts rms/channel into 8 ohms with both channels driven.

FM sensitivity is rated at 1.8 μV (IHF). The receiver features front-panel control of a 4-channel decoder (doubles as a second tape monitor), two auxiliary inputs, illuminated selector indicators, and a large tuning meter.

Circle No. 76 on Reader Service Card

IRC PACKAGED SWITCHES AND RELAYS

The most complete line of packaged switches and relays available through commercial distributors has been introduced by *International Rectifier Corp.* for use by hobbyists, technicians, and designers. The switch line consists of eight subminiature toggle and two subminiature pushbutton types. The 11 new relays are subminiature types intended for printed circuit board and other low-voltage applications.

Circle No. 77 on Reader Service Card

NORMAN LABS ACOUSTIC EQUALIZER

The bass response limitations of even the best bookshelf speaker systems can be be overcome with the *Norman* Labs Acoustic Equalizer Model Five. The Model Five allows the user to program the exact equalization curve his particular speaker systems need to provide flat bass out to the limits of audibility. Ten specific bass equaliaztion curves, for ten of the best selling bookshelf speaker systems, have been designed into the Model Five on the basis of anechoic chamber analyses. Bass, midrange, and treble controls of a flat, broadband design are provided.

Circle No. 78 on Reader Service Card

JENSEN ALIGNMENT TOOL SET

An outstanding kit of 25 tools for the technician is available from *Jensen Tools & Alloys.* Designated the Model 23C750, the kit includes virtually every alignment tool needed for work on r-f circuits in mobile and marine communication, radar, TV, and ham radio equipment. Each tool provides the necessary isolation between the user's hand and the equipment being aligned. Included are a universal aligner, long-reach core aligner, extra-thin tuning wand, bone-fiber tuner, Delrin-tipped i-f transformer aligner, oscillator aligners, and special aligners for Motorola, Stewart-Warner, Belmont, Zenith, RCA, and Westinghouse TV receivers.

Circle No. 79 on Reader Service Card

KANDU ELECTRONIC DRAFTING TEMPLATE

The Quad-Template is one of five new products recently introduced by *Kandu.* It is the most complete drafting aid ever offered to the engineer and hobbyist, containing all the symbols necessary for drawing schematic diagrams, logic diagrams, and PC etching guides. Many PC pad configurations are provided in various sizes to permit the user to select the size needed to solve his particular design problems.

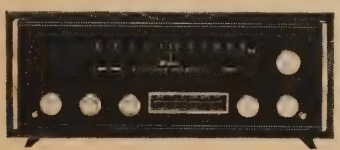
Circle No. 80 on Reader Service Card

KURZ-KASCH JUNCTION VERIFIER

The *Kurz-Kasch* Model JV-1505 Junction Verifier will check the operating condition of almost any solid-state junction device currently

FREE McIntosh CATALOG and FM DIRECTORY

Get all the newest and latest information on the new McIntosh Solid State equipment in the McIntosh catalog. In addition you will receive an FM station directory that covers all of North America.



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available, including bipolar transistors, diodes, rectifier assemblies, LED's, FET's, etc. It determines junction open/short conditions, current conduction, and the direction of current flow. The tester uses a unique digital technique that samples both forward and reverse current. A new circuit pulse syncs current in both directions, samples, compares, and then displays the results on the diode symbol screen on the front panel.

Circle No. 81 on Reader Service Card

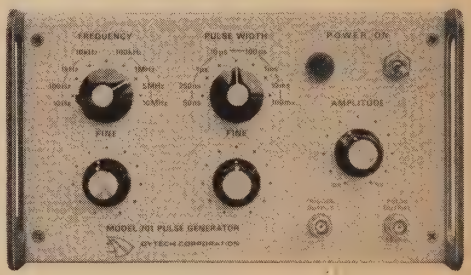
EDMUND STROBOSCOPE/TACHOMETER

A stroboscope and tachometer have been ingeniously combined into one compact unit by *Edmund Scientific Co.* for troubleshooting and maintenance use. As a strobe, it optically stops or slows the motion of any moving object; as a tach, it measures the speed or rate of motion of any rotating or moving object. A xenon flashtube in the unit is continuously flashed at a variable rate between 200 and 6000 pulses per minute, thus yielding readings of between 200 and 6000 rpm with 3% or better accuracy.

Circle No. 82 on Reader Service Card

DYTECH PULSE GENERATOR KIT

The professional Model 701 pulse generator (kit) available from *Dytech Corp.* has an all-IC design, sockets for all IC's, protected outputs, and is short-circuit proof. Other features include rugged chassis design, simple assembly



(aided by an assembly manual), and an operations and maintenance manual. The Model 701 never needs calibration once assembled. Pulse repetition rate is 10 Hz to 10 MHz; output pulse amplitude is 0-10 volts unterminated; rise and fall times are less than 5 ns, and pulse width is 50 ns to 100 ms. An oscilloscope trigger output is provided.

Circle No. 83 on Reader Service Card

PACE MOBILE CB TRANSCEIVER

Pace Communications is marketing their Model 223 two-way CB radio which is made in the U.S.A. and competitively priced with low-cost imports. The Model 223 provides all 23 channels of operations through a unique crystal synthesizing technique that compensates for drifts in crystal tolerance due to changes in temperature. Performance features include squelch con-

trol with 0.3 μV threshold, a volume control with an age circuit which holds essentially constant volume from 0.5 to 100,000 μV signals, and 5 watts of input power.

Circle No. 84 on Reader Service Card

METROTEC UNIVERSAL 4-CHANNEL DECODER

The Model SDW-Q universal 4-channel decoder made by *Metrotec Electronics, Inc.*, decodes CBS, SQ, and EV encoded records as well as synthesizes 4-channel sound from any two-channel source. The SDW-Q is the first synthesizer to retain full bass response in the rear channels by utilizing a special 300-Hz turnover in the matrix/phase shift circuitry. Features include a front-rear balance control, master volume control, tape monitor switch, source switch and matrix mode switches.

Circle No. 85 on Reader Service Card

MARANTZ HEADPHONES

The entry of *Marantz* into the stereo headphone line was recently announced by the introduction of the Model SD-1 low-impedance dynamic headphone. The 8-ohm SD-1 is equipped with a 10-ft coiled cord and a standard stereo phone plug. It features padded vinyl earpieces that assure isolation from external noise and extended bass response. Newly designed metallized Mylar driver diaphragms provide a smooth frequency respose from 20 to 20,000 Hz.

Circle No. 86 on Reader Service Card

EICO EXPANDS "FAILSAFE" LINE

The addition of seven new security products to their "Failsafe" line has been announced by *Eico*. Each product is designed to operate in conjunction with the Model FC-100 Security Control Center. They include the Model SD-12 leaf contact switches, SD-14 multipurpose contact swtches, SA-17 steel bell cabinet, A-115 chain-lock door alarm, A125 foil protector/adhesive, SD-60 smoke/power failure sensor, and SD-70 water sensor. Details of the Eico security system are available in the "Home Security Handbook," Model A-95.

Circle No. 87 on Reader Service Card

ELAC/MIRACORD TURNTABLE

The Elac/Miracord 50H Mark II automatic turntable which has all the features of the famous Miracord 50H as well as the most advanced tone arm mechanism ever made is being introduced by *Benjamin Electronic Sound*. Said to have the "softest touch in America," its unique tone arm mechanism offers the greatest stylus and record protection available in any turntable. The tone arm falls gently in the automatic as well as the manual modes. Additionally, pushbutton controls make the 50H Mark II easy to operate. A built-in strobe speed indicator and variable pitch control are professional touches for demanding users.

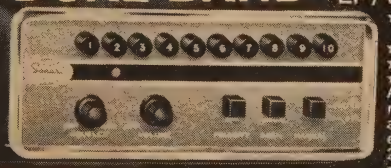
Circle No. 88 on Reader Service Card

HEATH 100-MHZ FREQUENCY COUNTER KIT

Heath has introduced their Model IB-1101 frequency counter which has a range from 1 Hz to beyond 100 MHz and a list of features unheard of before in "low cost" counters. The IB-1101 has an exclusive input circuit which accepts signal levels from less than 50 mV to greater than 200 V, depending on frequency, without damaging the instrument. The full 5-digit readout can be expanded to 8 digits by using the overrange circuitry. And to make accurate readout even easier, the decimal point is automatically placed with range selection. A 1-megohm input impedance and low input capacitance reduce the chance of circuit loading.

Circle No. 89 on Reader Service Card

DUAL BAND VHF/UHF LF/VHF 10 CHANNEL FM MONITOR RECEIVERS



★ Dual Channel non-restrictive programming of channels allows any combination of preselected channels to fit your needs
★ Priority channel-locks out all other signals
★ Any channel may be switched out of scanning sequence
★ Carrier Delay—You may hear mobile callbacks

A sophisticated professional automatic scanning monitor with the most reliable circuitry ever conceived. Has more power, more audio and more features than other monitors. New ceramic filter provides excellent adjacent channel operation in urban areas. All solid state. 2 watts of "Voice Fidelity," easy access plug in crystals. Dual purpose power supply for 117VAC and 12VDC, negative ground only.

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Comes with AC and DC power cables, mounting bracket, less crystals. Crystals $5.00 ea.

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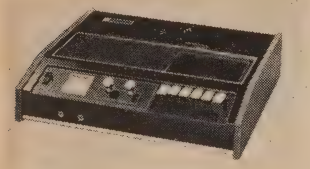
New kits for every interest in

Kit AR-1214 **169.95***

(AJ-1214 Tuner & AA-1214 Amp, 89.95* each)

New Heathkit 50-watt Stereo Receiver

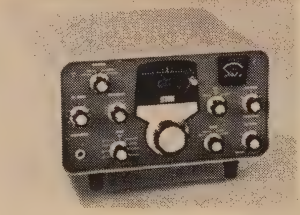
The new Heathkit AR-1214 AM/FM Stereo Receiver comes on with a great new look that's as practical as it is beautiful and the AR-1214 is a work of Heath audio excellence throughout. The amplifier section produces a clean 25 watts IHF, 15 watts RMS, per channel into 8 ohms. Two integrated circuits and two ceramic filters in the IF give this receiver a selectivity greater than 60 dB and superior amplifying/limiting characteristics. The phase lock multiplex demodulator gives 40 dB typical channel separation at less than 0.5% distortion. The preassembled FM tuning unit provides 2 uV sensitivity and a 2 dB capture ratio. The phono preamp section also uses integrated circuitry and has its own level controls so turntable volume can be set to coincide with tuner levels. All this in a money-saving kit project that's a pleasure from start to finish. Most circuitry mounts neatly on just three printed boards. The FM tuner is preassembled. Three evenings and just four simple alignment adjustments will have it all together. And the cabinet is included in the low price. Other features are: Black Magic panel lighting to hide the dial face when the receiver is off; flywheel tuning; stereo indicator light; headphone jack; speaker on/off button; built-in AM antenna. And there are complete tape monitor facilities so you can hear recorded material as it is committed to tape, make use of the many add-on components that use these jacks, or combine your AR-1214 with the matching AA-1214 Amp for a great sounding 4-channel system at a nice price. Stereo "separate" versions of the AR-1214 are also available: the AJ-1214 AM/FM Stereo Tuner at 89.95*; and the AA-1214 Stereo Amp at 89.95*. Both prices include cabinets. For a bold new sound in your listening room, order your Heathkit AR-1214, today. 16 lbs.



Kit AD-110

Heathkit Stereo Cassette Deck 129.95*

The AD-110 Stereo Cassette Deck offers a typical frequency response of 30-12 kHz for full fidelity reproduction of all mono and stereo cassettes, including chromium-dioxide. The built-in record bias adjustment requires no external equipment, utilizes the front-panel meter and a built-in reference. Features include precision counter, automatic motor shutoff, preassembled and aligned transport mechanism. Compatible with any quality mono or stereo system. 12 lbs.



Kit SB-313 **339.95***

New Heathkit SB-313 SWL Receiver

Covers 9 switch-selected bands between 3.5 & 21.8 MHz; receives SSB, CW, and AM with professional quality. 5 kHz AM crystal filter supplied, separate SSB & CW crystal filters optional. Solid-state circuit including 4 MOSFETs. IC crystal calibrator provides markers every 100 kHz or 25 kHz. Plug-in boards & wiring harness simplify assembly. 22 lbs.

Kit HW-7 **69.95***

New Heathkit HW-7 CW QRP Transceiver

Work the globe on "flea-power" with this 3-band QRP CW transceiver featuring VFO & provision for xtal transmit operation. Covers CW portion of 40, 20, & 15 meters. Solid-state circuit. Sensitive Synchrodyne detector. Built-in sidetone & relative power meter. Operates from optional AC power supply (14.95*) or 12V batteries. 6 lbs.

See them all at your local Heathkit Electronic Center...or send for FREE catalog

HEATHKIT ELECTRONIC CENTERS — ARIZ.: Phoenix, 2727 W. Indian School Rd.; **CALIF.: Anaheim,** 330 E. Ball Rd.; **El Cerrito,** 6000 Potrero Ave.; **Los Angeles,** 2309 S. Flower St.; **Pomona,** 1555 Orange Grove Ave. N.; **Redwood City,** 2001 Middlefield Rd.; **San Diego (La Mesa),** 8363 Center Dr.; **Woodland Hills,** 22504 Ventura Blvd.; **COLO.: Denver,** 5940 W 38th Ave.; **CONN.: Hartford (Avon),** 395 W. Main St. (Rte. 44); **FLA.: Miami (Hialeah),** 4705 W. 16th Ave.; **GA.: Atlanta,** 5285 Roswell Rd.; **ILL.: Chicago,** 3462-66 W. Devon Ave.; **Downers Grove,** 224 Ogden Ave.; **IND.: Indianapolis,** 2112 E. 62nd Ave.; **KANSAS: Kansas City (Mission),** 5960 Lamar Ave.; **MD.: Baltimore,** 1713 E. Joppa Rd.; **Rockville,** 5542 Nicholson

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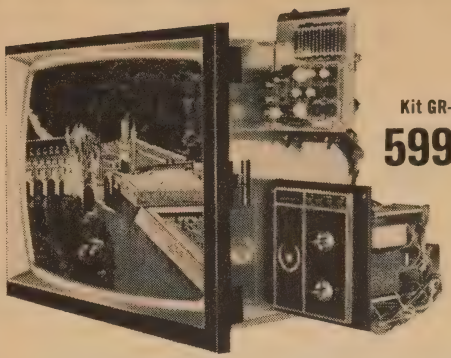
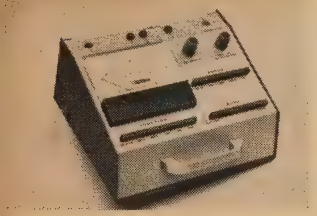
Heathkit GR-900 25V TV...the most exciting set we've ever offered!



Kit GR-900
599.95*

UHF/VHF detent power tuning heads up an impressive list of GR-900 deluxe features. Push a button and you scan either UHF or VHF channels, in either direction, with detent action locking in on the 12 VHF and any 12 preselected UHF channels. New voltage-controlled varactor UHF tuner and a newly designed VHF tuner with MOSFET contribute to better fringe-area reception and increased sensitivity. A new angular tint control for "normal" or "wide angle" color demodulation minimizes tint and flesh tone change when you switch channels or when programs change. Other features include "instant on" with override; automatic fine tuning; adjustable tone control; stereo-hi-fi audio output; automatic chroma control; adjustable video peaking; adjustable noise limiting; gated AGC; illuminated channel identification. For total armchair control, there's even an optional wireless remote control. The exclusive Heath MTX-5 ultra-rectangular bright tube measures a full 25 inches diagonal, 315 sq. in. viewing area — has a specially etched face plate to cut glare, with each color dot projected against solid black background for extra crispness. The built-in dot generator and tilt-out convergence panel are periodic adjustment aids you'll find only on Heathkit sets. And a built-in volt-ohm meter and simplified troubleshooting section in the manual permit self-servicing should the need ever arise. The new Heathkit catalog lists four beautiful cabinets for the GR-900, plus the exciting new custom wall mount that allows you to build the set into a wall. Brighten your life with the Heathkit GR-900... now! 125 lbs.



Kit IT-121 **49.95***

New Heathkit IT-121 FET Tester

Tests transistors, diodes, FETs, SCRs, triacs, unijunction transistors in or out of circuit. 5 current ranges measure leakage as low as 1 uA and collector currents as high as 1A. Gain (DC Beta), transconductance (GM) and leakage values read directly on large meter face. Special battery testing circuit gives meter indication of self-contained power supply. 6 lbs.

Kit CI-1040 **29.95***

New Heathkit CI-1040 Inductive Timing Light

Features extra bright daylight-use flash and all new triggering method. Special low-voltage inductive trigger pickup coil lets you connect light while engine is running, eliminates direct connections to spark plug, prevents interference with other test instruments connected to engine. High-impact, shock-proof plastic case. 4 lbs.

Kit GD-348
89.95*

New Heathkit Deluxe Metal Locator

Spots metal objects as small as a dime underground, searches under water up to 2 ft. deep. Unit sounds off only when metal is neared, tone gets louder as you approach. Convenient grip-mounted controls. Handle telescopes, head swivels to fold into neat flat package for carrying in optional leather carrying case with shoulder strap (6.95*). Headphones (4.50*) and battery (1.50*) are optional. Order your GD-348 today. 6 lbs.

Lane; **MASS.: Boston (Wellesley),** 165 Worcester St.; **MICH.; Detroit,** 18645 W. Eight Mile Rd. & 18149 E. Eight Mile Rd.; **MINN.: Minneapolis (Hopkins),** 101 Shady Oak Rd.; **MO.: St. Louis,** 9296 Gravois Ave.; **N.J.: Fair Lawn,** 35-07 Broadway (Rte. 4); **N.Y.: Buffalo (Amherst),** 3476 Sheridan Dr.; **New York City,** 35 W. 45th St.; **Jericho, L.I.,** 15 Jericho Turnpike; **Rochester,** Long Ridge Plaza; **OHIO: Cincinnati (Woodlawn),** 10133 Springfield Pike; **Cleveland,** 5444 Pearl Rd.; **PA.: Philadelphia,** 6318 Roosevelt Blvd.; **Pittsburgh,** 3482 Wm. Penn Hwy.; **TEXAS: Dallas,** 2715 Ross Ave.; **Houston,** 3705 Westheimer; **WASH.: Seattle,** 221 Third Ave.; **WIS.: Milwaukee,** 5215 Fond du Lac.

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CIRCLE NO. 19 ON READER SERVICE CARD

Electronics Library

INSTRUMENTS AND MEASUREMENTS FOR ELECTRONICS

by Clyde N. Herrick

This book presents a survey of basic test instruments and related measurement techniques. It covers the theory of measurement and applications and operating theory for each equipment item. Discussed in six categories are electrical indicating instruments, generators, bridge devices, electronic display instruments, tube and transistor checkers, and electronic counters and frequency meters. Special features include material on probability and error analysis, and information on the applications and limitations of each instrument. Selecting the correct instrument for each type of measurement and proper care and maintenance are stressed.

Published by McGraw-Hill Book Co., 330 West 42 St., New York, NY 10036. Hard cover. 560 pages. $13.95.

HOME SECURITY & SAFETY INSTALLATION HANDBOOK

In general, this handbook discusses home security and safety and advises readers on how to plan the installation of home security systems. The text uses as an example the new alarm and detection system manufactured by the publishers, but the guidance offered is applicable to most other home security systems and products. Covered in instructions and illustrations are descriptions of various components, wiring and installation of sensors and switches, use of window foil and connectors, and several related topics.

Published by Automated Alarms Corp., 116 South Ave., Garwood, NJ 07027. Soft cover, 32 pages. $1.00.

AUTOMATIC CONTROL SYSTEMS

by Ben Zeines

This textbook discusses the various principles and mathematical techniques used in analyzing automatic control systems. Emphasis is placed on the classical topics and procedures which have already demonstrated their usefulness. Among the topics covered are the Laplace transform; servomechanisms; motors and generators; amplifiers, modulators and demodulators; and frequency-response, time-response, and root-locus analyses. The mathematical prerequisites are trigonometry, algebra, and complex number theory. Additional math techniques are provided to enable the student to understand the operation and performance characteristics of automatic control systems.

Published by Prentice-Hall, Inc., Englewood Cliffs, NJ 07632. Hard cover. 222 pages. $12.00.

USING ELECTRONIC TESTERS FOR AUTOMOTIVE TUNE-UP

by Albert Wanninger

Complete information and operating instructions for all commonly-available electronic devices used for auto tune-up are provided in this new book. Early chapters show how to isolate faulty components by circuit tracing. Emphasis is placed on the proper coordination of the ignition system. Full coverage is given to tune-up kits, individual instruments, and console analyzers.

Published by Tab Books, Blue Ridge Summit, PA 17214. 256 pages. $7.95 hard cover; $4.95 soft cover.

COMMERCIAL RADIO OPERATOR THEORY COURSE

by Martin Schwartz

This course has been written for the purpose of preparing prospective radio operators for the FCC Radiotelephone First Class and Second Class licensing examinations. The subject matter covers the examination requirements for FCC Elements 3 and 4. Included in the text are numerous FCC-type multiple-choice questions.

Published by Ameco Publishing Corp., 314 Hillside Ave., Williston Park, NY 11596. Soft cover. 448 pages. $5.95.

RADIO AMATEUR OPERATING HANDBOOK

by Marshall Lincoln

Amateur radio is composed of two basic functions—experimenting and communicating. This book deals primarily with the latter function. It is not a technical book on electronics but a practical working guide to all facets of on-the-air operating activities.

Published by Editors And Engineers, Div. of Howard W. Sams & Co., Inc., 4300 West 62 St.,

Indianapolis, IN 46268. Soft cover. 160 pages. $4.95.

RADIOTELEPHONE EXAMINATION KEY AND ANSWERS

by Alexander A. McKenzie

This book is intended as a complete aid and review for those about to take the FCC exam for Radiotelephone Third Class operator permit. For this purpose, no other textbook is needed. All the information necessary to pass the endorsement test for limited broadcast station operation is also presented.

Published by McGraw-Hill Book Co., 330 West 42 St., New York, NY 10036. Soft cover. 336 pages. $5.95.

THE RADIO AMATEUR'S V.H.F. MANUAL Third Edition

Though the new edition of this popular Manual retains the basic form and content of its predecessors, it has been completely revised for vhf and uhf conditions of the 1970's. Three new chapters on FM and repeater principles and practices have been added. Some 70 pages on antennas offer the most complete information in this field available to the amateur reader. Also, the Manual contains construction projects for the home builder of vhf gear.

Published by The American Radio Relay League, Inc., Newington, CT. 06111. Soft cover. 352 pages. $2.50.

TELEVISION THEORY AND SERVICING

by Clyde N. Herrick

While emphasizing solid-state technology, this book gives devices, circuits, and systems used in TV a balanced treatment. It covers theoretical concepts and servicing and includes discussions on closed circuit and cable TV equipment. Troubleshooting and test equipment are stressed. Also, a lengthy and thorough discussion of television installation is provided.

Published by Reston Publishing Co., Reston, VA 22070. Hard cover. 468 pages. $15.00.

NEW TITLES FROM THE PUBLISHERS

From Tab Books, Blue Ridge Summit, PA 17214:

199 Electronic Test & Alignment Techniques by Art Margolis. 224 pages. $7.95 hard cover; $4.95 soft cover.

Solid-State Projects For the Experimenter by Wayne Green. Hard cover. 224 pages. $6.95.

RTTY Handbook by Wayne Green. 320 pages. $8.95 hard cover; $5.95 soft cover.

Basic Color Television Course by Stan Prentiss. 420 pages. $9.95 hard cover; $6.95 soft cover.

From Howard W. Sams & Co., Inc., 4300 West 62 St., Indianapolis, IN 46268:

Transistor Specifications Manual, Fifth Edition. Soft cover. 160 pages. $4.50.

Solid-State Servicing, by William Sloot. 160 pages. Soft cover. $4.95.

Questions & Answers About CB Operations, Second Edition, by Leo G. Sands. Soft cover. 112 pages. $2.95.

ABC's of Electronics, Second Edition, by Farl J. Waters. Soft cover. 160 pages. $3.95.

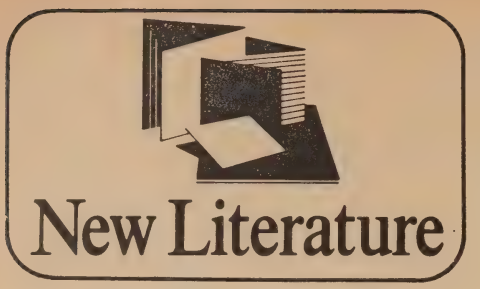
From McGraw-Hill Book Co., 330 West 42 St., New York, NY 10036:

Solid-State Device Theory by Phillip Cutler. Soft cover. 232 pages. $5.95.

Industrial Electronics: A Text-Lab Manual, Second Edition, by Paul B. Zbar. Soft cover. 264 pages. $8.50.

Transistor and Integrated Electronics, Fourth Editon, by Milton S. Kiver. Hard cover. 675 pages. $12.50.

CIRCLE NO. 31 ON READER SERVICE CARD



JERROLD TV/FM ANTENNA GUIDE

A 10-page guide entitled "How To Put Up A TV/FM Antenna" is available from *Jerrold Electronics Corp.* It discusses antenna selection, masts, lead-in cable, lightning protection, multiset systems, and how to install TV/FM antennas. The guide gives step-by-step instructions on various types of home antenna installations and includes hints on how to get maximum signal to the receiver as well as how to avoid interference. Address: Jerrold Electronics Corp., 401 Walnut St., Philadelphia, PA 19105.

"HOW-TO" BOOKLET ON PC BOARDS

"How To Make Printed Circuit Boards," a comprehensive instruction book for the engineer who makes prototypes and the low-volume producer has just been published by *Development Design Technology, Inc.* It covers the PC board process from artwork to etching and drilling. Cost breakdowns are given so that the various methods of production can be evaluated for any given requirement. Included in the booklet is a catalog of supplies and equipment needed to produce PC boards. Address: Development Design Technology, Inc., Dept. PE, 5901 N. Cicero Ave., Chicago, IL 60646.

IRC PRODUCTS CATALOG

The 1972-73 Commercial Products Catalog is now available from the Semiconductor Division of *International Rectifier Corp.* It contains details on a wide range of products from replacement components for home entertainment and industrial electronic equipment to components for hobbyists. The catalog contains photos of the products, case diagrams of the devices, and price information. Address: International Rectifier Corp., Semiconductor Div., 233 Kansas St., El Segundo, CA 90245.

B&K TEST INSTRUMENT CATALOG

Dynascan Corp. recently announced the release of their latest B&K test instruments catalog, No. BK-73. Its listings include eight new items: a single- and a dual-trace scope, both with triggered sweep; a FET and a digital VOM; a VOM with resettable electronic overload protection; a transistor curve tracer for use with an auxiliary scope; and a high-voltage (30 kV) probe. Other items include a sine/square wave generator, tube testers, sweep/marker generator, CRT tester rejuvenator, the Model 1077B Television Analyst, etc. Address: Dynascan Corp., 1801 W. Belle Plaine Ave., Chicago, IL 60613.

MOUNTAIN WEST ALARM BOOKLET

A new alarm equipment booklet called "Space Age Security" has been announced by *Mountain West Alarm Supply Co.* It lists and describes over 350 intrusion and fire alarms. Products are described in detail regarding applications, operating principles, and specifications to allow skilled technicians to make the right choices. Address: Mountain West Alarm Supply Co., 4215 North 16 St., Phoenix, AZ 85016.

AVANTI CB EQUIPMENT CATALOG

Avanti R&D's new Citizens Band Communications Catalog describes the company's complete line of base station, mobile, and marine antennas; trunk-lid and deck mounts; co-phasing harness kit; and other mobile accessories including two switch boxes and a transmitter-to-antenna matching box. Address: Avanti Research & Development, Inc., 3337 W. Fullerton Ave., Addison, IL 60101.

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CIRCLE NO. 44 ON READER SERVICE CARD

Surplus Scene

By Alexander W. Burawa, Associate Editor

GET TO KNOW YOUR DEALERS

MOST experimenters never get to see the premises of the dealers on the Surplus Scene, much less the dealers themselves. In general, surplus purchases are made through the impersonal (and sometimes rather slow) mails. The buyer, therefore, has little or no opportunity to become acquainted with the dealers.

Beginning with this month's column, and continuing periodially, we will present profiles of Surplus Scene dealers so that you can familiarize yourself with some of the dealers. To start the ball rolling, Profile No. 1 focuses on a company which has not been mentioned before in this column. Actually, it is two affiliated companies. Solid State Sales (325 Elm St., Cambridge, MA 02139) stock and sell all types of solid-state components, including transistors, diodes, and linear and digital integrated circuits.

The parent company of Solid State Sales is Eli Heffron & Sons (same address) which should ring some bells for people familiar with the test equipment end of the surplus market. This company deals exclusively in professional and laboratory-type surplus test and measurement equipment made by such big names as Tektronix, Hewlett Packard, etc.

Eli Heffron & Sons began selling surplus military gear during World War II. Since then, they have painstakingly built up quite a reputation as a leading supplier of used OEM (original equipment manufacturer) equipment. Solid State Sales, obviously, is newer to the scene; but their reputation is no less enviable.

As is true of all suppliers of used equipment, Eli Heffron & Sons obtain their merchandise from various sources—research and development labs, companies relocating or going out of business, the military, and the space agencies. Solid State Sales, on the other hand, get most of their items from production overruns and dealer overstocks.

Eli Heffron & Sons have no standard catalog since their inventory depends solely on what is available to them at any given time. However, if you need a specific type or model of instrument, you can ask the company in writing or call 617-547-4005. Solid State Sales does have a catalog (in addition to their monthly ads in this magazine). However, if you don't see what you want or need, you can write or call the company at the same address and telephone number.

Of prime importance to the mail-order customer is the dealer's policy on filling orders. Both Eli Heffron & Sons and Solid State Sales say that all orders, without exception, are processed and shipped on the day received. For items no longer in stock, substitutes that are similar or identical in performance to the ones ordered (except for test equipment, unless the customer says a substitute is acceptable) will be shipped. If substitutes are not available, the companies refund the balance of payment instead of holding it for back order. ◈

A NOTE TO SURPLUS DEALERS

It is our policy, in the Surplus Scene, not to be partial to any given dealer. To do so, we must be made aware of the various dealers on the scene. So, we solicit your help in putting together a complete file of dealers and catalogs. If your company has not been mentioned in this column, please send your most recent catalog or flyer to: Surplus Scene Editor, POPULAR ELECTRONICS Including Electronics World, One Park Ave., New York, NY 10016.

ELECTRONICS MARKET PLACE

NON-DISPLAY CLASSIFIED: COMMERCIAL RATE: For firms or individuals offering commercial products or services, $1.50 per word (including name and address). Minimum order $15.00. Payment must accompany copy except when ads are placed by accredited advertising agencies. Frequency discount: 5% for 6 months; 10% for 12 months paid in advance. **READER RATE:** For individuals with a personal item to buy or sell, $1.00 per word (including name and address.) No minimum! Payment must accompany copy. **DISPLAY CLASSIFIED:** 1" by 1 column (2⅝" wide), $185.00. 2" by 1 column, $370.00. 3" by 1 column, $555.00. Advertiser to supply cuts. For frequency rates, please inquire.

GENERAL INFORMATION: First word in all ads set in bold caps at no extra charge. All copy subject to publisher's approval. All advertisers using Post Office Boxes in their addresses **MUST** supply publisher with permanent address and telephone number before ad can be run. Closing Date: 1st of the 2nd month preceding cover date (for example, March issue closes January 1st). Send order and remittance to Hal Cymes. **POPULAR ELECTRONICS** Including **ELECTRONICS WORLD,** One Park Avenue, New York, New York 10016.

FOR SALE

FREE! bargain catalog. Fiber optics, LED's, transistors, diodes, rectifiers, SCR's, triacs, parts. Poly Paks, Box 942, Lynnfield, Mass. 01940.

GOVERNMENT Surplus Receivers, Transmitters, Snooperscopes, Radios, Parts, Picture Catalog 25¢. Meshna, Nahant, Mass. 01908.

ROCKETS: Ideal for miniature transmitter tests. New illustrated catalog. 25¢. Single and multistage kits, cones, engines, launchers, trackers, rocket aerial cameras, technical information. Fast service. Estes Industries, Dept. 18-K, Penrose, Colorado 81240.

LOWEST Prices Electronic Parts. Confidential Catalog Free. **KNAPP,** 3174 8TH Ave. S.W., Largo, Fla. 33540.

ELECTRONIC PARTS, semiconductors, kits. FREE FLYER. Large catalog $1.00 deposit. BIGELOW ELECTRONICS, Bluffton, Ohio 45817.

REGULATED POWER SUPPLY

This supply has five regulated voltages. 24 vdc @1.6 amps,26.5 vdc @ 3.25 amps, 18 vdc @6.6 amps.,14 vdc @2.9 amps, 12 vdc @ 1 amp. Highly regulated and filtered,all voltages fused, Rack or bench mount. Designed for leading computer mfg. Original cost over $250. Complete with data sheets, circuit diagram etc.

STOCK NO.F5025 49.50 ea.

POWER TRANSISTOR/HEAT SINK ASSEMBLY

Westinghouse 1561-0404 (similar to 2N3055, mounted on double ribbed heat sink, with TO-3 socket and .2 ohm emitter resistor. 75 watts. A pair makes an entire amplifier output stage.

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CIRCLE NO. 12 ON READER SERVICE CARD

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RADIO—T.V. Tubes—36¢ each. Send for free catalog. Cornell, 4213 University, San Diego, Calif. 92105.

CONVERT any television to sensitive, big-screen oscilloscope. Only minor changes required. No electronic experience necessary. Illustrated plans. $2.00. Relco-A33, Box 10563, Houston, Texas 77018.

MECHANICAL, ELECTRONIC devices catalog 10¢. Greatest Values —Lowest Prices. Fertik's, 5249 "D", Philadelphia, Pa. 19120.

SENCORE, B&K Test Equipment Unbelievable Prices. Free Catalog and Price Sheet. Fordham Radio, 265 East 149th Street, Bronx, N.Y. 10451.

ELECTRONIC Ignition. Various Types. Information 10¢. Anderson Engineering, Epsom, N.H. 03239.

METERS—Surplus, new, used, panel or portable. Send for list. Hanchett, Box 5577, Riverside, CA 92507.

PYROTECHNICAL chemicals, casings, tools, supplies, fuse, literature. Giant, illustrated catalogue/handbook includes formulas, instructions—50¢, with samples—$1.00. Westech, Box 593, Logan, Utah 84321.

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ELECTRONIC COMPONENTS—Distributor prices, Free catalog. Box 2581, El Cajon, California 92021.

ANTIGRAVITY, experiment and theory, Rushed—$2.00. U.S. Inquiries. Intertech 7A1, Box 5373, Station-F, Ottawa, Canada.

JAPAN HONG KONG DIRECTORY. World products information. $1.00 today. Sekai Shogyo Annai, Hillyard, Washington 99207.

EUROPEAN and Japanese bargains catalogs. $1 each. Dee, P.O. Box 9308, North Hollywood, Calif. 91609.

BURGLAR Alarm Systems equipment, dealers and private. Write: United Security, Box 2428, Dublin, Calif. 94566.

50 MEGAHERTZ LOW COST COUNTER

Here is a new item, featured because of numerous customer suggestions. We have taken the basic power supply, chassis and cover from our clock kit, and by substituting a new front panel and printed circuit board, have made a lowest cost frequency counter. The unbelievable low cost is due to our use of our large stock of unused surplus nixies, the new 74196 50 MHz decade counter, and the commonality of parts with our other kits. Readout is to six decades, time base is 1 second, 0.1 seconds, or external. Design is modular, for ease of construction, compactness, and expandability.

- ☐ 50 MHz six digit counter, using line frequency as time base, complete except for cover $97.50
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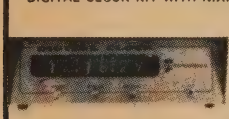
BUILD YOUR OWN ELECTRONIC CALCULATOR FOR ONLY $108.00!

A complete calculator kit, complete with self contained power supply and case. Indispensible in the home, office or school. Simple enough for a child to build. Some of the features of the calculator are as follows:

• MOS integrated circuits (extra large scale integration) reduce the number of components to a minimum, for easy assembly • Displays eight digits on large size seven segment displays. • Full function complement keyboard features addition, subtraction, multiplication, division, alternate display, multiplication by a constant, clear all, clear entry, and decimal point set. • Sixteen digit entry and sixteen digit results are possible with alternate display key. • Leading zeroes suppressed • Chain operation • All integrated circuits and displays are socket mounted and replaceable.

So reliable and simple to build, we can make this guarantee: If for any reason you cannot succeed in getting your calculator to function properly after completing construction, for a flat handling fee of $10.00, B and F will repair and ship back your calculator anywhere in the USA. This applies regardless of the age of the assembler, barring gross negligence or the use of acid core solder in construction.

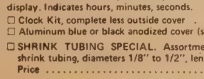
DIGITAL CLOCK KIT WITH NIXIE DISPLAY



We have well over 20,000 surplus nixies in stock, and because of this bargain putchase we can sell a complete digital clock kit for less than the usual cost of the display tubes only. We provide a complete etched and thru-plated circuit board, all integrated cifcuits, complete power supply, display tubes, I.C. sockets and a nice front panel with polaroid visor. We have never seen anyone offer this kit for less than $100.00 before. Includes BCD outputs for use as with timer option. May be wired for 12 or 24 hour display. Indicates hours, minutes, seconds.

- ☐ Clock Kit, complete less outside cover $57.50
- ☐ Aluminum blue or black anodized cover (specify) . $ 4.50
- ☐ SHRINK TUBING SPECIAL. Assortment of 200 pieces of shrink tubing, diameters 1/8" to 1/2", length 1/2" to 2" . $1.25 Price $1.25

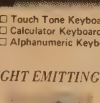
KEYBOARDS



Three keyboards are available; 20 key calculator keyboard, 40 key alphanumeric, , and 12 key touch tone. All have separate contacts carried out to edge connector.

- ☐ Touch Tone Keyboard . $ 9.50
- ☐ Calculator Keyboard . $14.50
- ☐ Alphanumeric Keyboard $29.00

LIGHT EMITTING DIODE NUMERIC DISPLAY



This display is excellent for small portable electronics, such as DVM's, calculators, etc. Equivalent to Montsanto MAN 3A. Operates from 5 volts, 20 milliamperes, with 47 ohm dropping resistor.

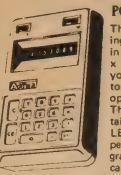
$3.25 Each
10 For $27.50

- ☐ Complete counter kit, 7490, 7475 latch 7447, printed circuit board, led readout . . . $9.50

LATEST HARD-TO-GET SEMICONDUCTORS

- ☐ MUS 4988 silicon uni-lateral switch. Useful for voltage sensitive switch, sweep generators, etc. . . . $1.00
- ☐ MIS A64 PNP high current Darlington transistor. Super-high gain in small package. . . . . 2/$1.00
- ☐ MPS A14, same as above, NPN. . . . . 2/$1.00

THIS MONTHS FEATURE ITEM



POCKET CALCULATOR KIT

This is the kit you have been waiting for. So compact it actually fits in a shirt pocket (3-13/16 x 4-5/8 x 1-1/4). It performs every function you would expect in a desk calculator, including constant and chain operation, and full floating decimal. The unit is powered by self contained batteries, and uses 8 digit LED displays. The calculations are performed by a single 40 pin integrated circuit, which can truly be called large scale integration (LSI). As a student, engineer, salesman, accountant, or anyone who would like fast accurate answers, this calculator fills the bill, and at a price that unquestionably makes this the lowest price high quality calculator available.

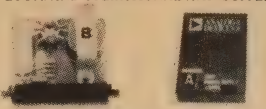
- ☐ Pocket Calculator Kit $75.00

RECHARGEABLE BATTERY/CHARGER KIT

This option allows the throw-away alkiline battery to be replaced with a nicad battery, and includes a charger to recharge this battery. The unit may be run during the recharge cycle.

- ☐ Battery/Charger Kit $17.50

LOGIC AND OPERATIONAL AMP' SUPPLIES



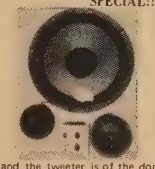
- ☐ Figure A, potted logic supply, 5 Volts at 1 Ampere, short circuit proof, ultra high regulation, ultra low ripple $16.00
- ☐ Figure A, potted Op Amp supply, +15 Volts, and -15 Volts at 0.5 Amperes. Mfg. by Analog Devices, similiar to their model 902. Short circuit proof, ultra high performance. $29.00
- ☐ Figure B, 5 Volt 1 Amp supply, regulated by Fairchild 9305, short circuit protected. $9.75
- ☐ Same as above, in kit form $7.75
- ☐ Mating connector for above $1.00
- ☐ 5 Volt 5 Amp regulated supply, by Blulyne, (not shown). $29.00

LIGHT EMITTING DIODES

Montsanto MV 50 or equivalent LED's. Now less expensive than filamentary bulbs. At this price wire them into logic circuits as status indicators, build low cost counters or use them as panel lites. Rated at 10 - 40 Ma @2V.

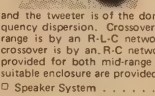
- ☐ 10 LED's $3.00
- ☐ 100 LED's $25.00
- ☐ 1000 LED's $200.00

LOUDSPEAKER SYSTEM COMPONENT SPECIAL!!



We have made an excellent purchase of an excess inventory of a local manufacturers speaker systems although we aren't allowed to mention the manufacturers name, the specs should make it self evident. The woofer is a 12" free-edge (acoustic suspension) unit, with 2" voice coil and a 2 lb. magnet. The mid-range is a 5" unit and the tweeter is of the dome type, for best high frequency dispersion. Crossover between woofer and mid-range is by an R-L-C network, while high frequency crossover is by an R-C network. Balance controls are provided for both mid-range and tweeter. Plans for a suitable enclosure are provided.

- ☐ Speaker System . . . . . $29.00 ea./2 for $55.00



CALCULATOR CHIP SPECIAL

B and F has purchased a quantity of MOS large scale integration chips for calculators. We are not allowed to mention the manufacturers name, however, the specs should make them self-evident.

- ☐ Set "X" - Four 24 pin I.C.'s, BCD output, 16 digit, fixed automatic decimal point, possible memory expansion, constant $29.00
- ☐ Set "Y" - Single 40 pin, 7 segment output, 12 digit, fixed automatic decimal, no constant . . . $15.00
- ☐ Set "Z" - Single 40 pin I.C., 7 segment output, 8 digit, floating point, constant $19.50

LINEAR DEVICES, OP AMPS, REGULATORS

- ☐ 709 High performance Op-Amp . . . . . $.50
- ☐ 711 Dual Comparator . . . . . $.50
- ☐ 723 Regulator $1.25
- ☐ 741 Compensated Op-Amp. . . . . $.50
- ☐ 558 Dual 741 . . . . . $1.00
- ☐ LM309 5 Volt 1 amp Regulator, TO-3. . . . $2.25

FAIRCHILD VOLTAGE REGULATOR

Fairchild UGH7805 5 Volt 1 amp voltage regulator. Perfect for logic supplies, very compact $1.95

AIRCRAFT/AUTO/BOAT QUARTZ CRYSTAL CHRONOMETER

Revolutionary!, was the reaction of our customers when they saw our latest kit. Measuring only 2-1/2" x 2-1/2" x 4", and accurate to 10 seconds a month, this chronometer promises to entirely replace mechanical clocks in cars, boats and airplanes.

Fits into a standard 2-1/4" instrument panel cutout. The displays are bright L.E.D. displays that should last a lifetime. Setting controls are recessed and operate from a pointed object such as a pencil point or paper clip, in order to keep non-authorized hands off. The clock should only have to be reset at very great intervals, or in the event of power loss (i.e. replacing battery in car). The clock is wired so that the timing circuits are always running, but the displays are only lit when the ignition is on, resulting in negligable power drain. The low price is only possible because of a new one chip MOS clock circuit, developed for quartz crystal wristwatches.

Operates form 10-14 Volts D.C. An accessory unit which mounts on the back adapts the unit to 20-28 Volts for twin engine aircraft and larger boats using 24 Volt ignition. Know how disgusted you are with the usual car clock? Order this fine unit now for rallying, sports events, navigation, or just to have a fine chronometer that will give you a lifetime of superbly accurate time.

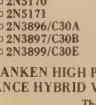
- ☐ Quartz Chronometer, Kit Form $59.50
- ☐ Quartz Chronometer, Wired $99.50
- ☐ 24 Volt Adapter $10.00

HIGH POWER SCR's

SCR's - invaluable for high power applications, motor speed controls, lighting circuits, welding controls, etc. Never before at this low price. Brand new packaged devices, complete with data sheet and 24 page consumer applications manual.

☐ 2N5062	Plastic 100V 1 amp	$.35
☐ 2N5064	Plastic 200V 1 amp	.40
☐ 2N4169	100V/8 amp stud	1.45
☐ 2N4170	200V/8 amp stud	1.65
☐ 2N4172	400V/8 amp stud	1.95
☐ 2N3525	400V/3 amp press fit	.95
☐ 2N1772/C15A	100V/8 amp stud	1.75
☐ 2N1774/C15B	200V/8 amp stud	1.95
☐ 2N1777/C15D	400V/8 amp stud	2.50
☐ 2N1844/C20A	100V/12 amp stud	1.75
☐ 2N1846/C20B	200V/12 amp stud	1.95
☐ 2N5169	200V/20 amp stud	3.75
☐ 2N5170	500V/20 amp stud	4.75
☐ 2N5171	700V/20 amp stud	6.75
☐ 2N3896/C30A	100V/25 amp stud	2.95
☐ 2N3897/C30B	200V/25 amp stud	3.95
☐ 2N3899/C30E	500V/25 amp stud	4.95

SANKEN HIGH POWER, HIGH PERFORMANCE HYBRID VOLTAGE REGULATORS



These hybrid regulators are easy to use, requiring no external components. Excellent for operational amplifier supplies, logic supplies and other high performance applications. All regulators have less than 50 millivolts ripple and better than 1% line and load regulation, some models far exceeding this specification.

- ☐ SI3120E 12 Volts, 1 Ampere $2.25
- ☐ SI3150E 15 Volts, 1 Ampere $2.25
- ☐ SI3240E 24 Volts, 1 Ampere $2.25
- ☐ SI3050E 5 Volts, 1 Ampere $2.25
- ☐ SI3554M 5 Volts, 3 Amperes $7.00

ALL ITEMS WHERE WEIGHT NOT SPECIFIED POSTAGE PAID IN THE U. S. A.

Phone in charges to (617) 531-5774 or (617) 532-2323. BankAmericard – Mastercharge. $10.00 minimum. No C.O.D.'s please.

master charge $10.00 Minimum Charge BANKAMERICARD

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FREE Kit Catalog: Shortproof powersupply $39.50. Ultrasonic Alarm $37.25. SWTPC, Box B32040, San Antonio, Tex. 78284.

FREE Catalog. Parts, circuit boards for Popular Electronics projects. PAIA Electronics, Box C14359, Oklahoma City, OK 73114.

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Learn the cost of Professional Alarm Equipment. Know how it is installed. Discover how you can save Hundreds-Of-Dollars by installing your own system. See the latest in technology such as *LASER BEAMS, INFRARED BODY HEAT DETECTORS* and *ELECTRONIC SIRENS*. 1972 "Handbook & Catalog". 84 pages, just $1.00 postage and handling. $1.00 is credited to first order.

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SURPLUS electronics for everyone. Free catalog. U.S. inquiries. ETCO, 464 McGill, Montreal, Canada.

WRITE for our free 32 page catalog. It lists resistors (14 different types, in kits and singly), 1542 tube types, 3024 different transistor types, many transistor kits, rectifiers in kits and singly, condensers of various types, tools, wire, antennae, phonograph cartridges and needles, speakers, CRT boosters, controls, switches, T.V. tuners, yokes, fly-backs, etc. Hytron Hudson, Dept. PE, 2201 Bergenline Ave., Union City, N. J. 07087.

ELECTROENCEPHALOPHONE: brainwave monitor. Professional biofeedback instruments. J&J, 8102-E, Bainbridge, Wash. 98110.

DIGITAL and analog computer modules. LED numeric display kits. FREE LITERATURE. Scientific Measurements, 2945 Central, Wilmette, Illinois 60091.

ELECTRONIC ORGAN KITS, KEYBOARDS for music synthesizers and organs. Every component for organ circuitry. 25¢ for catalog. Devtronix Organ Products, 5872 Amapola Drive, San Jose, Calif. 95129.

AUTOMOBILE BURGLAR SYSTEM with system connected even HOT WIRING will not start motor $7.95 complete. VANSONS MFG. & SALES, 10175 Breidt, Tujunga, Calif. 91042.

OSCILLOSCOPE improvement. Add trigger sweep and dual trace to any scope using low cost kits. HTP, Box 901, Cupertino, Calif. 95014.

LATEST snooping countermeasures: Manual $10.00. Negeye, Box 1036X, Anderson, Indiana 46015.

WE SELL CONSTRUCTION PLANS—gold recovery unit!—silver recovery unit—infra-red scope—x-ray fluoroscope—alternator adapter—200 watt inverter—electronic insect trap—burglar alarm system—chemical formulary (home products)—electroplater—plans $5.00—plus many more!—ask for **FREE** catalog—creative products, 1551 east loop 820, Dept. E-1072, fort worth, texas 76112.

RESISTORS: Carbon Composition brand new. All standard values stocked. ½ Watt 10% 50/$1.00; ¼ Watt 10% 40/$1.00. 10 resistors per value please. Minimum order $5.00. Postpaid. PACE ELECTRONIC PRODUCTS, Box 161-P, Ontario Center, New York 14520.

DIAGRAMS—TV, Radio, etc. $2.00. Techservas, Box 1167, Berkeley, Ca. 94701.

CB Radios in quantity direct from Japan at fraction of U.S. prices. Send $2.00 for information on 30 Japanese companies. K. Englert, 1263 Warner Ave., Los Angeles, Calif. 90024.

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SWLS, HAMS. 30 HZ RECEIVER SELECTIVITY continuously adjustable to flat response. Lossless transistorized filter plugs into headphone jack. $17.95. Send for brochure. Autek Research, Box 1494C, Canoga Park, Calif. 91304.

SPEAKER CROSSOVER coils and parts. Build your own crossovers. Design guide 25¢, catalog free. SPEAKERLAB, Dept. P, 5500 35th NE, Seattle, Wash. 98105.

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SWL's FREE antenna info, catalog of insulators, wire, coax, balun. Palomar Engineers, Box 455, Escondido, Calif. 92025.

PCB's etched and drilled. Single boards to small production runs. Dan Rodman, Rt. 2, Box 92, Brandon, Wisconsin 53919.

SEMICONDUCTOR SUPERMART—FREE CATALOG listing Motorola, RCA, Fairchild, National, HEP transistors and integrated circuits. Other components for building Popular Electronics projects. Circuit Specialists Co., Box 3047, Scottsdale, AZ. 85257.

ELECTRONIC Ignitions (3 models), VHF/UHF monitors, crystals. Southland, Box 3591, Baytown, Texas 77520.

COMPUTER ELECTRONICS—Complete course teaches basic of Logic Design, Handy devices you can build! Free details. DYNASIGN, Box 60-A2, Wayland, Mass. 01778.

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Q.T.—Quick Tinplate solution is all that is necessary to put a professional, protective finish on p.c. boards and small metal parts. Sample Pint—$3.50. C.D.C., Box 82475, Oklahoma City, Oklahoma 73108.

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7400	.26	.25	.23	.22	.21	74160	1.89	1.79	1.68	1.58	1.47
7401	.26	.25	.23	.22	.21	74164	1.89	1.79	1.68	1.58	1.47
7402	.26	.25	.23	.22	.21	74166	1.98	1.87	1.76	1.65	1.54
7403	.26	.25	.23	.22	.21	74176	1.62	1.53	1.45	1.36	1.28
7404	.28	.27	.25	.24	.22	74177	1.62	1.53	1.45	1.36	1.28
7405	.28	.27	.25	.24	.22	74180	1.20	1.13	1.07	1.01	.95
7406	.52	.50	.47	.44	.42	74181	5.20	4.90	4.59	4.28	3.98
7407	.52	.50	.47	.44	.42	74182	1.20	1.13	1.07	1.01	.95
7408	.32	.30	.29	.27	.26	74192	1.98	1.87	1.76	1.65	1.54
7409	.32	.30	.29	.27	.26	74193	1.98	1.87	1.76	1.65	1.54
7410	.26	.25	.23	.22	.21	74196	1.98	1.87	1.76	1.65	1.54
7411	.28	.27	.25	.24	.22	74197	1.98	1.87	1.76	1.65	1.54
7413	.58	.55	.52	.49	.46	74198	2.81	2.65	2.50	2.34	2.18
7416	.52	.50	.47	.44	.42	74199	2.81	2.65	2.50	2.34	2.18
7417	.52	.50	.47	.44	.42						
7420	.26	.25	.23	.22	.21	SCHOTTKY TTL					
7421	.26	.25	.23	.22	.21	74S00	1.11	1.08	1.02	.96	.90
7423	.80	.76	.72	.68	.64	74S01	1.14	1.08	1.02	.96	.90
7425	.50	.48	.45	.43	.40	74S03	1.14	1.08	1.02	.96	.90
7426	.34	.32	.31	.29	.27	74S04	1.37	1.30	1.22	1.15	1.08
						74S05	1.37	1.30	1.22	1.15	1.08
7430	.26	.25	.23	.22	.21	74S08	1.14	1.08	1.02	.96	.90
7437	.56	.52	.50	.48	.45	74S09	1.14	1.08	1.02	.96	.90
7438	.56	.53	.50	.48	.45	74S10	1.14	1.08	1.02	.96	.90
7440	.26	.25	.23	.22	.21	74S15	1.14	1.08	1.02	.96	.90
7441	1.73	1.64	1.55	1.46	1.37	74S20	1.14	1.08	1.02	.96	.90
7442	1.27	1.21	1.14	1.07	1.01						
7443	1.27	1.21	1.14	1.07	1.01	74S21	1.14	1.08	1.02	.96	.90
7444	1.27	1.21	1.14	1.07	1.01	74S40	1.37	1.30	1.22	1.15	1.08
7445	1.71	1.62	1.53	1.44	1.35	74S50	1.14	1.08	1.02	.96	.90
7446	1.24	1.17	1.11	1.04	.98	74S51	1.14	1.08	1.02	.96	.90
						74S60	1.14	1.08	1.02	.96	.90
7447	1.16	1.10	1.04	.98	.92						
7448	1.44	1.37	1.29	1.22	1.14	74S64	1.14	1.08	1.02	.96	.90
7450	.26	.25	.23	.22	.21	74S65	1.14	1.08	1.02	.96	.90
7451	.26	.25	.23	.22	.21	74S73	1.98	1.87	1.76	1.65	1.54
7453	.26	.25	.23	.22	.21	74S74	1.98	1.87	1.76	1.65	1.54
						74S76	1.98	1.87	1.76	1.65	1.54
7454	.26	.25	.23	.22	.21						
7460	.26	.25	.23	.22	.21	74S78	1.98	1.87	1.76	1.65	1.54
7470	.42	.40	.38	.36	.34	74S107	1.98	1.87	1.76	1.65	1.54
7472	.38	.36	.34	.32	.29	74S112	1.98	1.87	1.76	1.65	1.54
7473	.50	.48	.45	.43	.40	74S113	1.98	1.87	1.76	1.65	1.54
						74S114	1.98	1.87	1.76	1.65	1.54
7474	.50	.48	.45	.43	.40	74S140	1.37	1.30	1.22	1.15	1.08
7475	.80	.76	.72	.68	.64						
7476	.56	.53	.50	.48	.45	LINEAR IC'S					
7480	.76	.72	.68	.65	.61						
7482	.99	.94	.88	.83	.78	NE501	2.99	2.82	2.66	2.49	2.32
						NE526	3.59	3.38	3.17	2.95	2.74
7483	1.63	1.55	1.46	1.38	1.29	NE531	3.01	3.58	3.36	3.13	2.91
7485	1.43	1.35	1.28	1.20	1.13	NE531	3.01	3.58	3.36	3.13	2.91
7486	.58	.55	.52	.49	.46	NE536	7.31	6.88	6.45	6.02	5.59
7490	.80	.76	.72	.68	.64						
7491	1.43	1.35	1.28	1.20	1.13	NE537	7.53	7.09	6.65	6.29	5.76
						NE540	2.16	2.04	1.92	1.80	1.68
7492	.80	.76	.72	.68	.64	NE555	.98	.93	.88	.83	.78
7493	.80	.76	.72	.68	.64	NE560	3.57	3.36	3.15	2.94	2.73
7494	1.18	1.12	1.05	.99	.93	NE561	3.57	3.36	3.15	2.94	2.73
7495	1.18	1.12	1.05	.99	.93						
7496	1.18	1.12	1.05	.99	.93	NE562	3.57	3.36	3.15	2.94	2.73
						NE565	3.57	3.36	3.15	2.94	2.73
74100	1.52	1.44	1.36	1.28	1.20	NE566	3.57	3.36	3.15	2.94	2.73
74107	.52	.49	.47	.44	.42	NE567	3.57	3.36	3.15	2.94	2.73
74121	.56	.53	.50	.48	.45	N5111	.90	.86	.81	.77	.72
74122	.70	.67	.63	.60	.56						
74123	1.21	1.06	1.00	.94	.89	N5556	1.87	1.77	1.66	1.56	1.46
						N5558	.80	.76	.72	.68	.64
74141	1.63	1.55	1.46	1.38	1.29	N5592	3.40	3.29	3.00	2.80	2.60
74145	1.41	1.33	1.26	1.18	1.11	N5596	1.87	1.77	1.66	1.56	1.46
74150	1.63	1.55	1.46	1.38	1.29	709	.42	.40	.38	.36	.34
74151	1.20	1.13	1.07	1.01	.95						
74153	1.63	1.55	1.46	1.38	1.29	710	.42	.40	.38	.36	.34
						711	.44	.42	.40	.37	.35
74154	2.43	2.30	2.16	2.03	1.89	723	1.00	.95	.90	.85	.80
74155	1.46	1.39	1.31	1.23	1.16	733	1.90	1.80	1.70	1.60	1.50
74156	1.46	1.39	1.31	1.23	1.16	741	.44	.42	.40	.37	.35
74157	1.56	1.48	1.39	1.31	1.23	747	1.05	.99	.94	.88	.83
74158	1.56	1.48	1.39	1.31	1.23	748	.48	.46	.43	.41	.38

TRANSISTORS & DIODES

1N270	.15	.14	.13	.12	.11	.10	1N4003	.13	.12	.11	.10	.09	.08
1N751A	.30	.28	.26	.24	.22	.20	1N4006	.15	.14	.13	.12	.11	.10
1N914	.10	.09	.08	.07	.06	.05	1N4154	.15	.14	.13	.12	.11	.10
1N4001	.10	.09	.08	.07	.06	.05	2N3860	.25	.23	.21	.19	.17	.15
1N4002	.11	.10	.09	.08	.07	.06							

All IC's are supplied in 8-, 14-, 16-, or 24- pin DIP (Dual-in-line) plastic or ceramic package except for NE533, NE536, NE537, and NE540 which come in TO-5 package.

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500 μF, 15V ..... 20¢	10 μF, 50V ..... 15¢
1000 μF, 15V ..... 30¢	20 μF, 50V ..... 20¢
20 μF, 25V ..... 15¢	50 μF, 50V ..... 20¢
30 μF, 35V ..... 20¢	100 μF, 50V ..... 20¢
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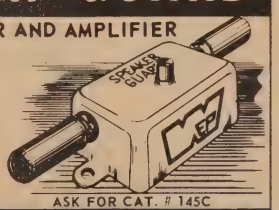

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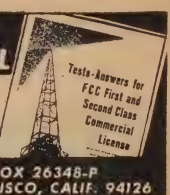

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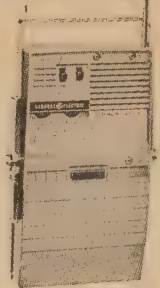

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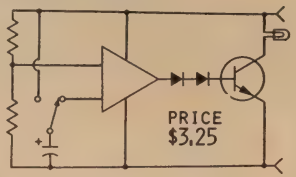

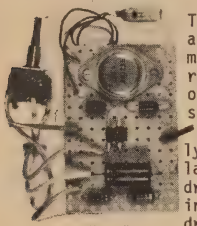

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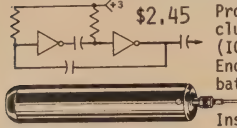

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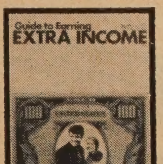

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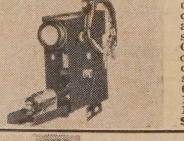

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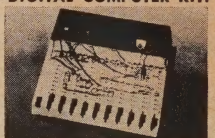

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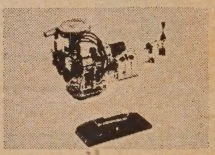

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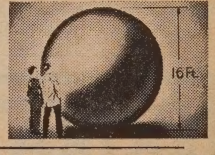

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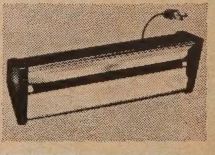

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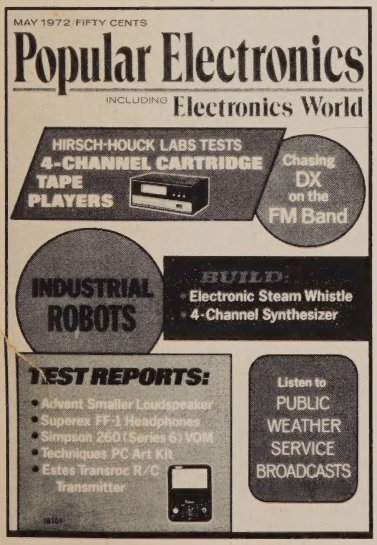

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